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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
The Foundry Trades' Equipment and Supplies Association

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The Ironfounders' National Committee

The news printed in our last issue, giving the aims and objects of this new body, as well as detailing the personnel of the enlarged main and executive committees has given general satisfaction. Previous criticism as to the composition of the executive committee being upon too narrow a basis has been largely remedied. That complete satisfaction has not yet been attained is indicated by the phrase "Special attention is being given to the needs for adequate representation of small firms. Suggestions for representation will be gladly received."

Satisfactorily to answer this question it seems to us necessary to contrast the existing structure of the ironfounding industry with the ideal organisation, and then draw the necessary conclusions. Conditions at the present time are:—The industry is well organised for research through the British Cast Iron Research Association, whilst none is better served for the collection of technical data and its dissemination than the foundry industry through the work of the Institute of British Foundrymen and its official organ. Matters germane to the training and education of the younger members of the industry are adequately dealt with, though greater interest could usefully be shown by the employers' organisations. A similar remark applies to costing, where full implementation of the Institute's findings is called for. The National Ironfounding Employers' Federation is organised through representation from district associations. It has, since Mr. Harold Judd became secretary, made commendable progress.

There are a number of sectional or group associations the most important of which is the British Ironfounders' Association. This body establishes nationally unified and normally economic selling prices by agreement with the Builders Merchants' Association and related bodies. It is regarded in well-informed business circles as a model of an intelligent trade co-operation. There are several other groups such as the "Chair," "Axlebox," "Green-sand Pipe" associations, all doing useful work in their particular fields. It will be noticed that the composition of the committee includes a number of "independent" foundries. We are not at all sure just what this means, but the result of a study of its fundamental implication would yield information of importance in the construction of a nation-wide organisation.

Here then are the conditions as they exist to-day, and they disclose all the necessary elements for the closest collaboration. An essential is a clear postulation of the aims and objects in such a way that an appeal is made to every foundry owner, be the foundry he controls large or small. The first thing to be noted is that it is a wartime organisation and as such is not necessarily likely to make an appeal to (*a*) those foundries engaged wholly upon important munitions of war as they well know that supplies will be forthcoming, and (*b*) those optimists who have convinced themselves that the war will be of a short duration. If there be need—as we believe there is—for an over-riding foundry organisation in wartime, it is equally obvious that such an organisation will be necessary to safeguard the interests of the foundry industry in the post-war clear up. Thus the policy of the I.N.C. should be extended to envisage such conditions.

What then is the ideal constitution of such a committee? Taking it for granted that it would have liaison with the Institute of British Foundrymen and the Cast Iron Research Association, then for industrial representation every country has realised that this must be of two kinds—district and manufacturing groups. Under any ideal organisation there should be no "independent" foundries. The manufacturing group associations would tend to increase with closer association. The National Ironfounding Employers' Federation is the obvious association to cover every foundry in the country, and the local organisations must be made to adopt exactly the same articles of association and rules and regulations. At the moment some of the district associations attached to the National association have quite different objectives. Some are purely confined to the obtaining of economic prices, whilst others are dealing with labour questions. Through well-organised district associations the small foundry owner would obviously be participating in the general conduct of the affairs of the industry. It will be noticed that out of the four aims set out by the I.N.C., three of them need for intelligent discussion the ascertainment of basic costs of production. Should the activities of the I.N.C. be expanded, it will be found that costs will enter into even more than 75 per cent. of the problems studied. Thus there must be an early recognition of this fact. There are a number of costing systems available for study—the British one evolved by the Institute of British Foundrymen, the American one sponsored by the A.F.A., and the German one which was smuggled out of that country by Mr. E. H. Salinger. Costing systems are like signposts, they only point the way. The I.N.C. must see that foundries not only install them, but utilise them for ensuring economic prices and for pointing out the blatant extravagances to be associated with some methods still

(*Concluded on page* 2.)

District Presidents

No. 4—LANCASHIRE BRANCH

MR. A. L. KEY.

Mr. Arthur L. Key is one of those exceptional individuals who have broken with tradition by migrating northwards. He is a true Cockney, having been born within the sound of Bow Bells. He served his apprenticeship with the firm of John Penn, marine engineers, of Greenwich, supplementing his practical training by studying various technical subjects at the Goldsmiths' Institute. By 1907 he had reached Birmingham after working his way through the usual stages of a skilled craftsman, charge hand, foreman and manager. Here he joined the British Foundrymen's Association (now the Institute of British Foundrymen), and thus ranks amongst its oldest members. For many years he has been resident in the Manchester area, where he has taken a profound interest in the work of the local Branch. He has been a frequent contributor to discussions, especially when they have had reference to cupola practice and the reorganisation of foundries. Two years ago, he participated in the International Foundry Congress at Düsseldorf, where he personally experienced something of both Nazi intolerance and German kindly hospitality. The honour which his colleagues have accorded him is certainly well deserved. His present position is that of foundry manager to J. Hodgkinson (Salford), Limited, engineers and general ironfounders.

The Ironfounders' National Committee

(*Concluded from page* 1.)

in vogue. This can only be done by the inspection of the books by I.N.C. district accountants, until a price list can be established for most grades of castings and continuously for those incapable of being classified. This may be unpalatable reading, but until some such method is established the large buyers, will with the first approach of a slump, twist the tails of the foundrymen to obtain uneconomic prices as they have invariably done in the past. As a policy we recommend the I.N.C. to form as many sub-committees as possible with very differing personnel in order to keep as large a membership as possible of foundry owners interested in their work. Finally we wish the I.N.C. every success in their laudable endeavour.

Foundry Ferro-titanium

The last diary to be issued by T. Rowlands & Company, Limited, of 23-27, Broomhill Street, Sheffield, contains a note on the use of T.A.M. foundry ferro-titanium. This alloy, which is added to cast iron, preferably at the furnace spout, commends itself because of its comparative low melting-point, something of the order of 1,300 deg. C. It contains 17 to 21 per cent. of titanium and also of silicon and less than 0.5 per cent. of either carbon or aluminium and is stated to dissolve readily. The effect of titanium is, it is claimed, to act as a deoxidiser, grain-refiner and graphitiser for cast iron, and a reducer of the average size of the graphite flakes. Where chromium has been incorporated in the composition, the use of titanium is said to prevent chilling in thin sections. It is recommended that large ladles in preference to small shanks be used for the incorporation of the alloy, which should be finely ground and added gradually and uniformly.

Looking Forward in Metals

BY "ONLOOKER."

After not much more than three months of war it has been decided to give the tin market a free hand to function as it likes, and no one can have been surprised to see the price in London soaring upwards in a really sensational manner. At the same time the quota for the first quarter of next year has been raised to 120 per cent. of the standard tonnages, so that, one way and another, it may be said that tin has really launched out on a course of freedom, its present state being really less trammelled than has been the case for a long time past.

After the initial upward jump of £40 or so the tin market in London has rather fallen away, and it would not be at all surprising to find that the American market also begins before long to ease off, for all restraint having been removed from production it will be found that buyers will be much less anxious than they were before. In the past, control of tin production has been used as a lever to raise prices to a level altogether out of proportion to the quotations of other metals and it is going to be very interesting to see what happens now that output is to be permitted on such a generous scale.

In the other base metals, however, no decontrol in price has taken place, and the general expectation is that if any upward revision is made in existing values the extent of the rise will not be very serious. On the other hand it seems very likely that the output curtailment scheme in copper which existed before the war has been allowed to lapse for the time being. Doubtless the structure and the machinery is retained, for it may well be that some day it will be necessary to put the scheme into being again, for it looks very much as if the copper industry is going to expand to an extent which, when a return to ordinary peacetime practice comes, will present very serious problems.

There was no planned production in spelter for the Zinc Cartel did not materialise, and the arrangement in lead consisted of an understanding between the producers concerned, but with both of these metals there is a strong upward tendency in the rate of output and the difficulties of the post-war period for them are not likely to be any less than in the case of copper. Mention may also be made of aluminium, where the control price is now £110 per ton, and on every hand efforts are being made to increase the amount available of this vital wartime commodity.

Post War Problems

Everyone recognises that stocks on hand after the war will be heavy, for secondary metal is bound to accumulate and virgin production will be kept going until the bell rings for the last round in the European trial of strength. What perhaps has not been quite so much considered is where these stocks will be lying and what their distribution will be. Again much depends upon the duration of the war, for over a fairly prolonged period it is surprising into what holes and corners metals will find their way. The deciding factor is, however, price, and in this connection the opinion is ventured that producers of tin are very pleased to see the American consumers filling up their shelves on the basis of the present inflated price. Generally speaking, of course, the converse is true, for at high prices the consumer buys as little as possible while the manufacturer keeps a short book so that the producer is left with the bulk of the world's metals on his hands. On the other hand, when metals pass through a slump period and values are abnormally low, consumers take kindly to the idea of accumulating stocks for they feel they have a good lock-up investment. The question is, how are prices going?

Random Shots

Beginning the new year in a black-out, it is fitting to remember with gratitude an inventor whose centenary fell in the year that has just been left behind. Working in an age which produced so many engineering geniuses, the name of William Murdoch has never received the recognition it would have done had he been a lone star in the century; but he has at last come into his own. It is a truism that one only appreciates a thing when one cannot have it, and now that town and country alike have reverted to the pre-Murdoch darkness, his invention takes on a new significance.

* * *

Even one's attitude to the moon has changed in these modern Dark Ages. Whereas a moonlit night was of yore an inspiration to poets to burst into verse, to lovers to burst into declarations, and to musicians to burst into sonatas, it now signals prosaic businessmen to their prosaic meetings and provides an excuse for one's mother-in-law to drop in for the evening. Perhaps, too, the old unkind superstitions which have surrounded the moon for generations will be forgotten gradually in the gratitude for its light-giving beams. To bury the spooks and ghosts for ever would be at least one good outcome of a dismal black-out age!

* * *

Incidentally, many readers will thank Mr. Barrington Hooper during this year on this score. His little chart of moonlight for the year is an idea brighter than the light it maps out. Hung by the telephone, one can visualise it next December being as thumb-worn as the directory itself, for there is moonlight to suit the whole family. Some evenings it will shine obligingly early for the youngster who wants to "go out to tea" with his school pal. A few nights later will see the not-quite-grown-up daughter flitting off to the pictures without mother throwing fits of apprehension; whilst later in the month she herself can tease her spouse to take her to a theatre, if he hasn't got one of his eternal meetings.

* * *

And whilst 1939 marked the centenary of the anti-black-out merchant, 1940 is the centenary of the introduction of the penny post—a system for which many have cause to be grateful during these long evenings, for it has provided one of the greatest hobbies man ever took to. Stamp collectors just love these long quiet evenings at home, for at last they have time to settle down to investigate the mysteries of wmks. and perfs.

* * *

One London Scot always spent New Year's Eve in the traditional manner associated with the Metropolis round St. Paul's. This year, however, being evacuated into the country, he had to find a different way of celebrating, so he went for a bus ride. It was a lovely ride, for it provided opportunities for celebration at every stop, as of the seven official stopping places, five of them were as follow: New Inn, Ship Inn, Royal Hotel, Bell Inn, and Parrot Inn. Even the parrot gave him the bird in the end.

* * *

"Dodge lorry driver wanted," says an advertisement. There should be no difficulty in finding one, for most people who go out in the black-out are experts at it now.

* * *

"Required, 145 yds. of 12 in. sewer for the Town Council," reads another advertisement. So that's what they do with them after their year of office!

"MARKSMAN."

Metal Cleaning Hygiene

AN AMERICAN CODE OF RECOMMENDED PRACTICES

(*Concluded from page* 442.)

TUMBLING MILL CLEANING PROCESSES

Continuous Type Tumbling Mills

Continuous tumbling mills vary considerably in design, but all depend on eventually removing all the dust and dirt when it becomes fine enough, due to tumbling action, to be carried away by the air flowing through the mill. The mill joints shall be dust tight and any hoods shall be close fitting to the shell to prevent excess air leakage. Not less than 400 ft. lineal velocity of air shall flow into all mill openings of any kind whatsoever, per minute.

If the exhaust ventilation for the continuous mill is provided only for removing flotation dust, the minimum velocity in the branch pipe shall be 4,000 ft. per min. when the branch pipe is connected to the hood or hoods on the mill. If provision is made for removing heavier particles sifted out from the mill into a hopper under the mill and such dust and dirt is removed by the exhaust system rather than by other means, then a minimum velocity of 6,000 f.p.m. shall be provided in the branch pipe removing such heavy material, and a minimum of 4,000 f.p.m. velocity shall be provided in the branch pipes connected to hoods for removing flotation dust from the mill. The air velocity in any header pipe connected to the branch pipe leading to continuous mills shall not be less than 4,000 f.p.m.

Batch-Type Tumbling Mills

Batch tumbling mills are of several types, but all operate on the same general principle of periodic loading, operating and unloading. The method of removing the dust and dirt from such mills is extremely important to prevent the escape of dust and dirt into the general atmospnere.

Stave Mills

Stave mills are those that have staves or slats for the outside construction of the mill shell with the staves spaced sufficiently apart for the dust and dirt to drop out through these openings. No regular means of exhausting these mills is provided. Such mills shall be housed in an exhausted enclosure which is substantially tight-fitting except for an air inlet opening into the housing to permit air flow through the housing to the exhaust pipe. The housing shall be substantially constructed of sheet metal. The cover or doors shall be close-fitting in the housing to prevent dust leakage and shall be kept in closed position when the mill is in operation. Covers and housings constructed of fabric material shall not be permitted.

The amount of exhaust ventilation applied to stave-mill housings or enclosures shall not be less than the following minimum requirements:

Inside dimension of stave mill not over 70 in. inside length.		Cubic feet of air to be exhausted per minute for mills not over 70 in. inside length.
Side of square mill.	Dia. of round mill.	
—	Up to 24 in.inc.	800
Up to 24 in. inc.	30 in.	900
30 in.	36 in.	980
36 in.	42 in.	1,335
42 in.	48 in.	1,745
48 in.	54 in.	2,210
54 in.	60 in.	2,725
60 in.	66 in.	3,300
66 in.	72 in.	3,925
72 in.	—	4,610

For mills in between the sizes listed above, the amount of air handled per minute shall be increased in proportion to the difference in size and volume of air, and such amount of air thus obtained added to the nearest smaller size listed above.

For mills longer than 70 in. inside dimension, the volume of air shall be increased in direct proportion as per the following formula:—

$$\frac{\text{Length longer than 70 in.}}{\text{70 in.}} \times \text{Volume of air for 70-in. mill.}$$

The air intake into the mill housing or enclosure shall be located at the front and bottom of the enclosure, and shall be of such size that the average air velocity is not less than 400 ft. per min. The minimum air velocity in the branch and header pipe connected to the enclosure shall be 3,600 ft. per min.

Internally-Ventilated Mills

Internally-ventilated mills are that type of all-metal construction where the air for ventilating and removing the dust and dirt generated in the mill is drawn into one end of the mill, passing through the mill and exhausted to the exhaust system by means of suitable pipe connections at the opposite end of the mill.

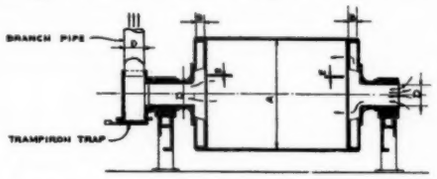


FIG. 1.—INTERNALLY-VENTILATED MILLS.

"A"—Inside dimension of mill		"D"—Inside diameter of exhaust branch pipe and hollow trunnion for mills not over 70 in. inside length.
Side of square mill.	Diameter of round mill.	
—	Up to 24 in. inc.	4 in.
Up to 24 in. inc.	30 in.	5 in.
30 in.	36 in.	6 in.
36 in.	42 in.	7 in.
42 in.	48 in.	8 in.
48 in.	54 in.	9 in.
54 in.	60 in.	10 in.
60 in.	66 in.	11 in.
66 in.	72 in.	12 in.
72 in.	—	13 in.

The velocity of air in the branch pipe "D" shall not be less than 5,000 f.p.m.

The diameter of the holes "E" should not exceed ¾ in., or slots may be used, but should not exceed ¼ in. wide.

The holes or slots, if punched out, shall have the enlarged taper side of the hole towards the heads. It is preferable to have the holes countersunk on the inside to avoid peening action.

The area of all holes in a head shall not be less than four times the area of "D."

The dimension "B" shall not be less than D/4 + 1 to obtain sufficient air passage space.

For any mills when inside cross-sectional dimension falls between any two dimensions listed above, use the branch pipe size corresponding to the larger dimension.

For mills larger than 72 in. cross-sectional dimension provide an air duct and branch pipe inside diameter in proportion to the pipe and air-duct area required for the 72-in. mills.

For mills larger than 70 in. inside length add 1 in. to the branch pipe and air duct inside diameter to the corresponding cross-sectional dimension for branch pipe size

Due to the fact that the product put into the mill obstructs the flow of air through the mill, care must be exercised in loading the mill to permit the passage of air. If the air passage in the mill is too restricted, the required amount of air for handling the heavy dust concentrations will be reduced, resulting in dust and dirt being dropped out of the air stream in the junction box tramp-iron trap. This type of mill shall be proportioned as shown in Fig. 1, in order to obtain the best possible air flow conditions.

These mills shall be well constructed and reinforced to prevent distortion in order that the covers may remain tight fitting and to prevent dust and dirt leakage in operation. A minimum velocity of 5,000 ft. per min. shall be maintained in the branch pipes connected to internally ventilated mills. The velocity in the header pipe connected to the branch pipes shall not be less than 4,000 ft. per min.

Duct-Ventilated Mills

Duct ventilated mills are that type of all-metal construction where the air for ventilating and removing the dust and dirt generated in the mill is drawn through two ducts diametrically opposed and located on the exterior of the mill shell. The mill shell has openings in the form of slots opposite the ducts and at every half revolution of the mill, a certain amount of dirt and dust sifts into the ducts to be carried away by the air stream. These ducts must be properly proportioned for any given size of mill and the duct areas must be maintained to proper size until the air stream reaches the exhaust pipe. With this type of mill the air flow is always constant, regardless of how closely the mill is packed with product, and there is little or no tendency for the dust and dirt to drop out of the tramp-iron trap. In addition to the exterior ducts, a small amount of air is exhausted from the mill interior to reduce the dusty atmosphere condition within.

This type of mill shall be proportioned as in Figs. 2 and 3, in order to obtain the best possible air flow conditions.

It is essential that the metal used for making the slotted holes feeding into the ventilating ducts be of high manganese content to reduce magnetic tendencies and to give a hard surface which will resist the peining and the closing over of the slots due to the tumbling action of the product in the mill.

A minimum velocity of 5,000 ft. per min. shall be maintained in the ducts on duct-ventilated mills. A minimum velocity of 5,000 ft. per min. shall also be maintained in the branch pipes connected to duct-ventilated mills. A minimum velocity of not less than 4,000 ft. per min. shall be maintained in header pipes connected to such branch pipes.

Existing Installations of Mills

Where there are existing installations of mills and the mill exhaust openings or branch pipes connected to the mills are smaller than required by this code, the velocity of the air in the branch pipe may be increased to obtain the volume of air that would be exhausted if the exhaust openings and pipe diameters corresponded to this code requirement.

Material Specification for All-Metal Batch-Type Mill Construction

Due to the fact that tumbling mills receive considerable abuse in operation and tend to warp and wear rapidly under various conditions, it is necessary that they be well constructed, reinforced and securely fabricated to eliminate distortion and prevent the cover and other joints from leaking dust and dirt.

It is recommended that all-metal batch-type mills that are not lined to resist abrasion be made of steel plate of not less than the following thicknesses:—

Inside cross-sectional dimensions—round or square mills.	Thickness of steel plate shell—in.	Thickness of steel plate heads—in.
Up to and inc. 24 in...	¾	Not less than ¼
Over 24 in. to 30 in. inc.	1	" " "
Over 30 in.	1¼	" " "

D

Mill Speeds

Batch-type tumbling mills should operate at a speed that will do a good job of cleaning and yet keep breakage to a minimum. When product is packed in a mill and the cleaning is accomplished more by the circulation of the stars, the peripheral speed of the mill shell may be as high as 275 ft. per min. For products loosely loaded in the mills, the peripheral speed should be considerably lower. Speeds of 225 ft. per. min. ordinarily produce good results.

Removal of Refuse Dropped by Mills

Tumbling mills of all types have a tendency to spill or drop dust and dirt and refuse from the mill, and this represents that part of the material removed from the product that is not carried away by the exhaust system. In the case of stave mills, it is impossible to carry away any of the material removed from the surface of the product except that which is fine and light enough to float in the air, and the balance of the refuse drops through the slats on to the floor. Wherever it is necessary to use such mills, the hazard of subsequently removing this material from the floor can be minimised if a hopper is provided under the floor into which this heavier material drops, and then the hopper is emptied in some safe manner. Even belt conveyors can be employed for conveying the material away to some safe place for disposal.

In the case of the internally-ventilated mills, the product packed into the mills usually obstructs the air flow to such an extent that in the initial operation of the mills, the dust concentrations are so heavy that the air volume and velocities provided in the exhaust system are not sufficient for conveying all of this material to the dust collector, with the result that considerable quantities of this refuse drop out through the tramp-iron trap on to the floor.

If the refuse dropped out of any type of mill on to the floor is of a highly siliceous or toxic nature, extreme care must be exercised in removing this material from the floor when it is shovelled into containers, to avoid the creation of a dusty condition. The sprinkling of the refuse with water helps to alleviate the dust. In extreme cases it may be necessary to provide the workmen with personal respiratory protective devices to prevent the inhalation of the dust.

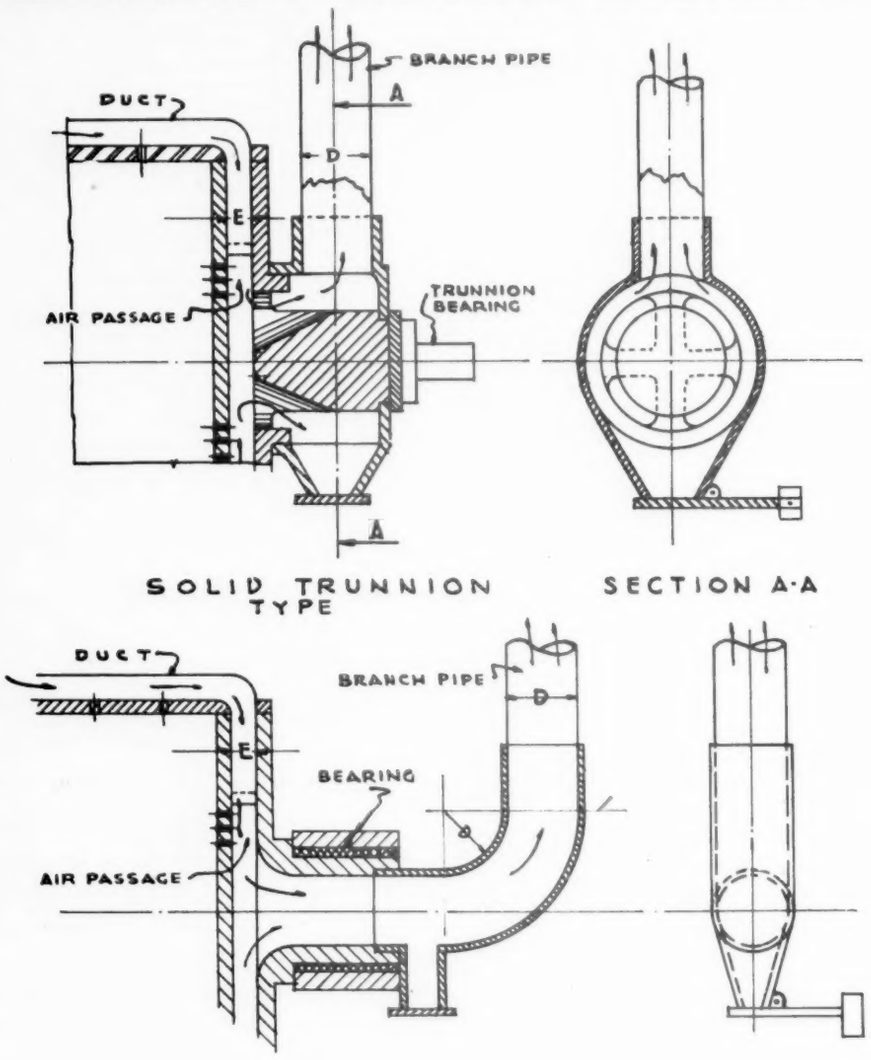


FIG. 2.—DUCT VENTILATED MILL (PATENTED).

For any mills when inside cross-sectional dimensions falls between any two dimensions listed on figure, use the duct and branch pipe sizes corresponding to the larger dimension.
For mills larger than 60-in. cross-sectional dimension provide ducts and branch pipe sizes in proportion to the size for the 60-in. mills.
For mills larger than 70 in. inside length use the next larger sizes of ducts and branch pipes.

Design of Exhaust Systems

The resistance of the mills to the flow of air through them varies greatly, depending upon the type, size, method of operating, and product. The manufacturer of the equipment should be consulted as to the resistance loss to be expected, and such information shall be given in terms of velocity pressure corresponding to the velocity in the connecting branch pipe exhausting the equipment. The following equipment will usually have resistances in terms of VP within the following ranges:—Continuous mills, 1.0 to 1.5; internally-ventilated mills, 2.5 to 4.0, and duct-ventilated mills, 2.0 to 4.0.

Testing Exhaust Systems

A pitot tube shall be used to measure the velocity pressure of the air flow in the branch pipes and headers of the exhaust system, and such measurements shall be taken in the centre of a straight portion of the pipe that is not less than ten pipe diameters down stream from an elbow or bend, or as near this location as the pipe installation will permit, and the velocity pressure shall not be less than that specified for the various velocities listed below as indicated by a manometer:

Minimum velocity of air required in pipe. Ft. per min.	Minimum centre pipe (V.P.). Ins. W.G.
3,600	0·97
4,000	1·21
5,000	1·88
6,000	2·70

All tests for air velocity shall be made with all branch pipes of the exhaust system fully opened at the same time.

ABRASIVE BLASTING PROCESSES

The abrasive blasting of metal parts embraces varied types of equipment, purposes, and methods of projecting the abrasives, as well as kinds of abrasive material employed. The personal element is extremely involved, particularly in those types of operations where the operator must be within, or adjacent to, the compartment when in operation.

Dust Exposures Involved.—The abrasive blasting process cleans the product rapidly, and therefore may produce large quantities of dust. The amount of dust is dependent upon the condition of the surfaces of the product, the amount of abrasives used per unit of time, the method of abrasive propulsion, and the kind of abrasive material used. Additional dust may be generated in the pneumatic and mechanical handling of the abrasives, and in cleaning the abrasives for re-use and disposal of refuse.

Due to the dust created in such operations, all types of equipment and auxiliary appurtenances shall be substantially built and so constructed that there is no outward leakage of dust to the general atmosphere when in operation and the exhaust equipment is operating. When leakage occurs, the operators are not only affected, but all other occupants in the immediate vicinity of the equipment are exposed. When the type of equipment is such that the operator must be within the blasting chamber in the direct presence of the dust created, the operator shall be protected by wearing suitable fresh, uncontaminated air-supplied respiratory equipment.

General Construction Specifications

Air Intake Openings.—Openings shall be provided in all units of the abrasive blasting equipment, and its appurtenances for the admission of ventilating air, so that there will be a definite flow of air of sufficient volume through the parts of the equipment to the exhaust system continuously to remove the dust created. Such openings provided shall be so located as to afford a uniform distribution of air flow through the parts to be exhausted, and the openings within range of the abrasives used shall be so

baffled or protected that abrasives will not ricochet through the openings to the outside of the equipment to cause an accident hazard or dust emitted to cause a health hazard.

Entrance, Product and Inspection Openings.—All entrance, product and inspection openings, manholes and doorways into the blasting chamber of the abrasive blasting equipment or to the pits, hoppers, conveyor housings and other abrasive cleaning rooms shall be close fitting and door joints properly baffled or sealed to prevent dust leakage or the escape of abrasives into the general atmosphere, particularly when there is a chance of the abrasives stream being directed at such openings. One method of sealing the joints tight to prevent dust leakage outward and the escape of abrasives is shown on Fig. 4, and consists of a rubber tube held in place in the

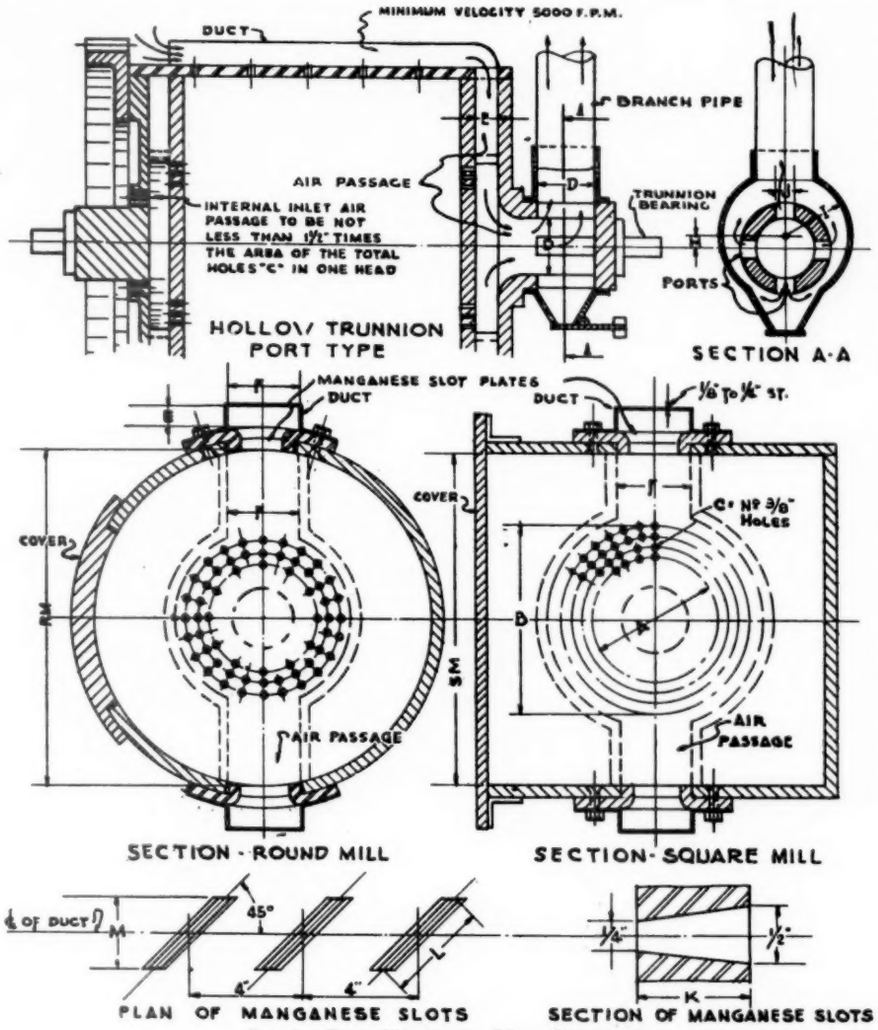


FIG. 3.—DUCT VENTILATED MILL (PATENTED)

SM.	RM.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	C.F.M. at 5,000.
												In.			
—	24	8	12	60	4	1·32	3·78	6	0·20	4·20	1·6	¾	3·10	2·25	435
24	30	9	15	95	5	2·28	4·96	7	0·25	3·25	2·0	1	3·53	2·50	680
30	36	10	18	128	6	2·68	6·02	8	0·31	6·30	2·4	1¼	4·68	3·31	980
36	42	11	21	173	7	3·01	7·08	9	0·35	7·35	2·8	1½	5·31	3·76	1,335
42	48	12	24	226	8	3·38	8·14	10	0·50	8·40	3·2	1¾	6·22	4·40	1,745
48	54	13	27	286	9	3·71	9·20	11	0·56	9·45	3·6	1½	7·08	5·01	2,210
54	60	14	30	355	10	4·10	10·22	12	0·62	10·50	4·0	1½	7·97	5·64	2,725
60	—	15	33	430	11	4·47	11·33	13	0·68	11·55	4·4	1¾	8·86	6·27	3,300

enclosures in the auxiliary appurtenances shall be completely closed and sealed when the equipment is in operation, and the door or opening joints shall be so designed or provided with gaskets so that dust and abrasives will not escape into the general atmosphere. Suitable fasteners or locking devices shall be provided to keep the doors or covers in a closed and tight position when the equipment is in operation.

All door openings or turntable openings into joint which is inflated when the doors or turntables are in closed position. Mechanical or electrical interlocks are provided so that the blasting operation cannot be started until the doors and turntables are in closed position and the tubes inflated.

Equipment Exhaust Requirement

Air intake openings provided for the purpose of admitting air into the equipment or appurtenances to remove the dust therein to the exhaust system shall be of sufficient area to admit the required volume of air and the average entrance velocity of the air into such openings shall be sufficient to prevent outward leakage of dust and shall not be less than 300 ft. per min. unless otherwise specified.

Wherever there are shutes or conveyors conveying the used abrasives, dust and refuse to the abrasive washing unit, the air transport velocity shall not be less than 6,500 ft. per min. and the air volume shall not be less than 100 cub. ft. per pound of abrasives and refuse handled.

Whenever there are shute or conveyor discharge openings discharging into the general atmosphere, the average velocity of air entering into the equipment at such opening shall not be less than 300 ft. per min.

Abrasive Blasting Rooms

Abrasive blasting rooms in which the operator is working within the room shall be provided with down-draft ventilation of not less than an average of 80 ft. per min. velocity over the entire projected floor area of the room and the air shall be exhausted from the room downward through the floor or on at least two sides of the room at the floor line, except that in specific instances cross ventilation may be used providing the average velocity shall not be less than 80 ft. per min. over the vertical cross-section of the room.

Abrasive Blasting Tunnels

Abrasive blasting tunnels are equipment in which the product to be cleaned passes into the cleaning room or chamber through an entrance opening by some means of conveyance and passes out of the room through an exit opening. Such plant may be equipped for automatic blasting or operators may be within the tunnel to perform the blasting operation. Entrance and exit openings shall be provided with vestibules of sufficient length or number of turns so that the baffling over the cross-sectional area of the vestibule openings provided for the prevention of the ricocheting of abrasives will be effective.

The baffling in each vestibule may consist of at least two sets of doors or three sets of flexible curtains made of abrasive resisting material. The spacing of the doors or curtains shall be such that at least one set of either remains in closed position when the product is passing through the vestibule, unless the product is so large that the blasting operation may be stopped during the time the product is being transferred into or out of the tunnel and in which event tightly sealed doors may be used at the entrance and exit openings. An average air velocity of at least 300 ft. per min. shall be drawn into the vestibules through the net open area of the doors or curtains.

The abrasive blasting portion of the tunnel, excluding the vestibules only, wherein operators are stationed for performing the abrasive blasting operations, shall be provided with down-draft ventilation of not less than an average of 80 ft. per min. velocity over the entire projected floor area of the blasting portion and the air shall be exhausted from the chamber downward through the floor or on at least two sides of the chamber at the floor line, except that in special instances cross-ventilation may be used providing the average air velocity shall not be less than 80 ft. per min. over the vertical cross-section of the chamber, except in cases where large bulky product is regularly passed through the tunnel, such as rolling stock, the amount of ventilating air may be reduced by providing for not less than 100 ft. per min. average air velocity over the net effective horizontal or cross-sectional area.

Rotary Abrasive Blasting Tables

Rotary abrasive blasting tables are equipment in which the product is loaded on to a hori-

zontal rotating table and passes into an enclosed chamber for abrasive cleaning. The exposed portion of the loading and unloading zone of the table shall be as small as possible so as to obtain the maximum distance between the entrance and exit openings in the chamber and the abrasive projecting units.

The entrance and exit openings shall be made as small as possible and shall be completely curtained with at least three sets of abrasion-resisting rubber-covered duck or other suitable material, spaced not less than 4 in. apart. Additional curtains shall be located within the chamber adjacent to the blasting units to minimise the escape of abrasives toward the entrance and exit openings. The volume of air exhausted from the chamber shall not be less than the equivalent of 20 cub. ft. per min. per sq. ft. of gross area of the inlet and outlet openings without the protective curtains in place.

Abrasive Blasting Mills and Hand Cabinets

Abrasive blasting mills, whether of the barrel or conveyor type, shall be ventilated at least equivalent to twenty air changes per minute, based on the empty cubical contents of the work chamber.

Wherever possible, product openings or openings through which the hands are extended should be closed dust-tight during operations, but in no event shall the average velocity of air entering all openings in the cabinet be less than 500 ft. per min. The amount of air exhausted from the cabinet shall be equivalent to at least twenty times the volume of the cubical contents of the cabinet per minute.

Loss of Abrasives

In order that usable abrasives may not be carried into the main exhaust system to the dust collection equipment and thereby be lost, the outlets from the blasting compartment shall be of sufficient area to prevent usable abrasives from being entrained in the exhausted air and such outlet openings should not have a velocity greater than 500 ft. per min. unless suitable abrasive traps are provided to return the abrasives and the necessary allowances for resistance to air flow caused by the trap shall be included in the resistance losses in the exhaust system.

Allowances for Compressed Air

When compressed air is used for the propulsion of the abrasives, the amount of compressed air discharged within the mill, room or cabinet shall be determined and added to the required amount of air for exhausting the abrasive cleaning equipment and auxiliary appurtenances. The amount of compressed air discharged increases as the blasting nozzles wear, and 50 per cent. shall be added to the discharged capacities of the total normal areas of all blasting nozzle areas when new. The amount of compressed air discharged for a given area and total nozzle area may be determined from Table I.

Design of Exhaust Systems

All abrasive blasting equipment and their auxiliary appurtenances shall be connected to exhaust systems and the minimum air velocity in any branch pipe or header pipe shall not be less than 3,600 ft. per min.

Testing Exhaust Systems.—A pitot tube shall be used to measure the velocity pressure of the air flow in the branch pipes and headers of the exhaust system and such measurements shall be taken in the centre of a straight portion of a pipe that is not less than ten pipe diameters downstream from an elbow or bend or as near this location as the pipe installation will permit and the velocity pressure as indicated by a manometer gauge shall not be less than 0.97 in. W.G. for 3,600 ft. minimum velocity.

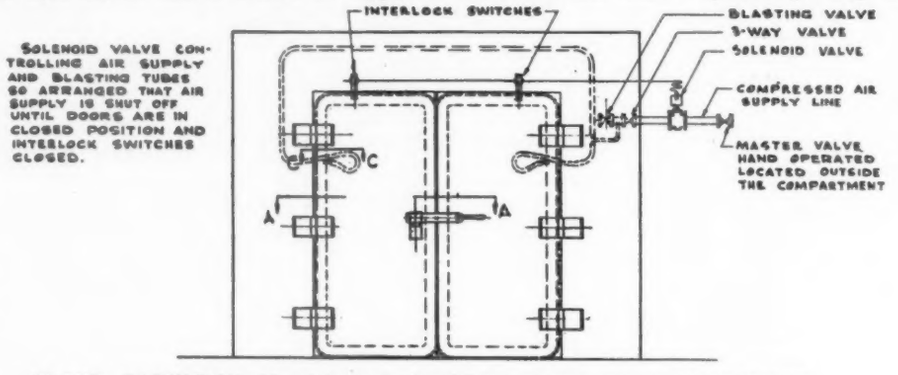
Respiratory Protection

All operators who must work in the direct presence and in contact with the dust and dirt created by the abrasive or hydraulic blasting and cleaning operations shall be provided with, and shall wear, fresh-air-supplied airline helmets or masks. The airline supplying fresh air to the helmets or masks shall not be less than ½ in. inside diameter. The helmets or masks shall be provided with a supply of fresh, filtered air and if such air is cold due to climatic conditions, the air shall be heated to at least 65 deg. Fah. before entering the helmet or mask. Compressed air shall not be used as a fresh air supply for any helmet or mask unless an adequate air filter is provided to remove all dust.

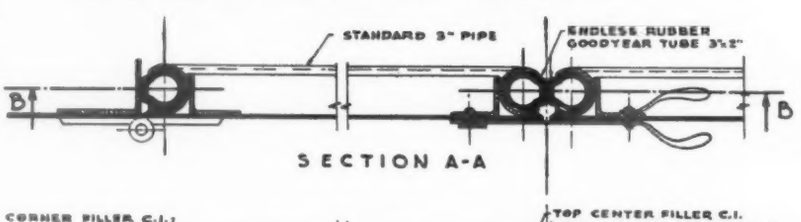
The amount of air to be supplied to any helmet or mask shall not be less than 14 cub. ft. of air per min. so that there will always be a sufficient volume of air present thoroughly to purge the helmet or mask equipment and prevent dust and dirt from entering the helmet or mask openings. No valves for controlling the air supply to the helmets shall be permitted.

Removing Abrasives from Product

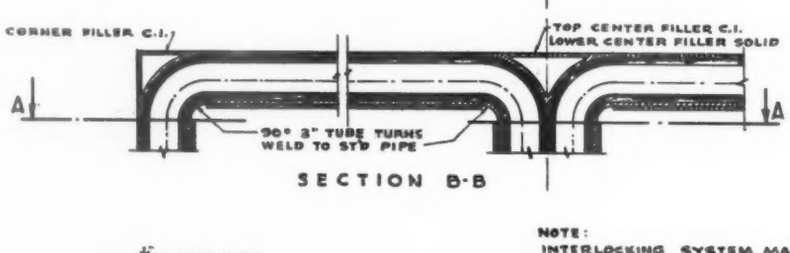
Wherever it is necessary to remove loose dust or abrasives from cavities in a product that has been blasted and such removal is accomplished with an air blast, such dusting operation shall be performed within the abrasive blasting equipment with the exhaust system operating and shall not be done outside in the general atmosphere so that the dust will contaminate the general atmosphere. If it is necessary to perform the dusting operation outside of the abrasive blasting equipment, such dusting operations shall be performed in a special cabinet or booth that is properly ventilated to prevent contaminating the general atmosphere.


INTERLOCK SWITCHES
BLASTING VALVE
3-WAY VALVE
SOLENOID VALVE
COMPRESSED AIR SUPPLY LINE
MASTER VALVE HAND OPERATED LOCATED OUTSIDE THE COMPARTMENT
SOLENOID VALVE CONTROLLING AIR SUPPLY AND BLASTING TUBES SO ARRANGED THAT AIR SUPPLY IS SHUT OFF UNTIL DOORS ARE IN CLOSED POSITION AND INTERLOCK SWITCHES CLOSED.
C
A
A

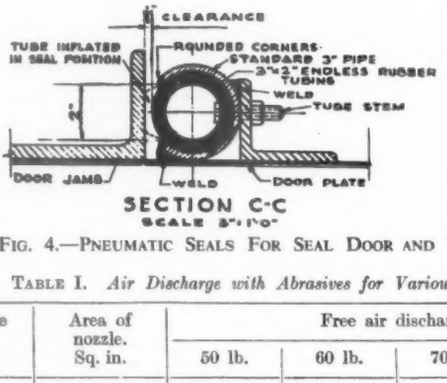
FRONT ELEVATION OF ABRASIVE BLASTING ROOM OR COMPARTMENT
SHOWING APPLICATION OF TUBE SEALS TO DOOR OPENINGS



SECTION A-A



SECTION B-B



SECTION C-C
SCALE 3"=1'0"

NOTE:
INTERLOCKING SYSTEM MAY BE EITHER ELECTRICAL OR PNEUMATIC.

FIG. 4.—PNEUMATIC SEALS FOR SEAL DOOR AND TURNTABLE OPENINGS (PATENTED).

TABLE I. *Air Discharge with Abrasives for Various Blasting-Nozzle Sizes and Pressures.*

Nozzle dia. In.	Area of nozzle. Sq. in.	Free air discharged. Cub. ft. per min.					
		50 lb.	60 lb.	70 lb.	80 lb.	90 lb.	100 lb.
3/32	0·02761	27·9	31·9	36·5	40·4	44·7	49·2
1/4	0·04909	49·5	57	64·6	72·3	80	88
5/32	0·07670	77·1	89·3	101	113	124	137
3/8	0·1104	111	129	145	162	179	197
7/32	0·1503	151	175	198	221	243	268
1/2	0·1963	197	228	258	289	320	350
9/32	0·2485	250	289	327	366	402	443
5/8	0·3068	309	357	405	452	499	547
11/32	0·3712	373	432	489	547	600	661
3/4	0·4418	444	514	582	650	717	786

Founders' Forum

Q.—Why does casting section affect the pouring temperature of bronze castings? Can this be made less critical? Indicate suitable pouring temperatures for various non-ferrous alloys.

A.—The effect of pouring temperatures on the production of bronze castings seems to be connected with the amount of gas present in the metal and the cooling rate required to maintain the gas in solution. For example, in metal liable to contain much gas better results are usually obtained by increasing the rate of solidification either by lowering the casting temperature or by chill moulds. Similarly, thin-sectioned castings are not so susceptible to variation in casting temperature as heavy articles. Accordingly, it would appear that if foundrymen take the necessary steps to prevent gas absorption during melting, as far as possible, or alternatively degasify the metal before casting, the effect of pouring temperature will be less critical and production will be facilitated.

Suitable pouring temperatures for some of the principal non-ferrous metals and alloys are shown in Table I. A useful rule to keep in mind for roughly determining the pouring temperature of sand-cast articles is to allow 15 per cent. superheat over the melting point for light work, 10 per cent. for average and 7 per cent. for heavy sections. In the case of ingot production 10 to 7 per cent. superheat is usually ample according to the size of ingot being produced.

In castings of variable thickness pouring temperature should be determined according to the metal section in the thinnest parts. This will, in the majority of cases, entail the use of a slightly higher temperature in the heavier sections, but this is an advantage rather than otherwise, providing definite precautions are taken for feeding and the metal is free from excessive gas.

Q.—What are the best methods of making test-bars in gunmetal and in high-tensile brass?

A.—In the first place, it should be emphasised that the true function of test-bars is to indicate metal quality. Accordingly, from the point of view of foundry control purposes, separately-cast bars are to be preferred wherever possible. In the case of short gunmetal test-bars, not exceeding 5 to 6 in. in length, the moulding method shown at A, Fig. 1, gives fairly satisfactory results. For longer bars better results are obtained by running from both ends, as shown at B. This latter type of bar also gives good results with nickel-silver and cupro-nickel, etc.

Test-bars in metal having high shrinkage, such as manganese bronze, Monel, etc., are usually made from either pattern C or D, Fig. 1, although type B may also prove satisfactory in many cases. Type E is often employed in Continental foundries, and has been claimed to give good results even with metals like stainless steel. It is important to note that the height of head on this latter bar must be at least equal to the test-piece section. Furthermore, the metal in the centre portion under the head must be thick enough thoroughly to feed the test-piece section.

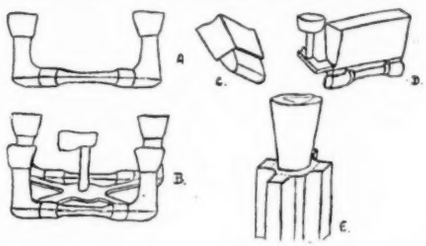


FIG. I—SUGGESTED TEST BAR CASTINGS FOR NON-FERROUS METALS.

TABLE I.—*Suitable Casting Temperatures for a Number of Non-Ferrous Alloys Arranged by Section Thicknes*

Metal or alloy.	Composition. Per cent.	Approx. melting point. Deg. C.	Pouring temp. for castings. Deg. C.		
			Light.*	Medium.*	Heavy.*
Aluminium	99 Al	657	760	730	700
Aluminium alloy	Y and R.R. types	620–635	730	710	690
Aluminium-silicon alloy	87–90 Al, 13–10 Si	570	700	660	620
Aluminium-copper alloy	93 Al, 7 Cu	630	730	710	690
Admiralty gunmetal	88 Cu, 10 Sn, 2 Zn	960	1,200	1,160	1,120
Aluminium bronze (ingots)	88 Cu, 9 Al, 3 Fe	1,045	1,200	1,150	1,100
Brass (castings)	73 Cu, 22 Zn, 4 Pb, 1 Sn	1,000	1,240	1,200	1,160
Brass (ingots)	70 Cu, 30 Zn	970	1,100	1,070	1,040
Brass (ingots)	60 Cu, 40 Zn	900	1,050	1,000	970
Copper	99 per cent.	1,083	1,200	1,160	1,130
Copper-nickel alloy	96 Cu, 4 Ni	1,120	1,280	1,250	1,220
Copper-lead alloy	70 Cu, 30 Pb	970	1,100	1,050	—
Copper-lead bronze	75 Cu, 21 Pb, 4 Sn	1,000	1,150	1,100	—
Cupro-nickel (castings)	30 Ni, 0·5 Si, 1 Mn, 1 Fe, Cu bal.	1,220	1,450	1,410	1,375
Cupro-nickel (ingots)	80 Cu, 20 Ni	1,180	1,360	1,300	—
Cupro-nickel (ingots)	70 Cu, 30 Ni	1,220	1,400	1,350	—
Gunmetal	85 Cu, 5 Sn, 5 Zn, 5 Pb	1,020	1,180	1,140	1,100
Leaded bronze	80 Cu, 10 Sn, 10 Pb	930	1,090	1,050	1,000
Manganese bronze	38 Zn, 0·7 Mn, 1 Fe, 0·5 Al, Cu bal.	875	1,050	1,000	960
Monel (normal)	1·5 Si, 1 Mn, 2·5 Fe, 66 Ni, Cu bal.	1,350	1,560	1,530	1,500
Monel (silicon)	2·75 Si, 1 Mn, 2·5 Fe, 66 Ni, Cu bal.	1,320	1,530	1,500	1,470
Monel ("S")	3·75 Si, 1 Mn, 2·5 Fe, 66 Ni, Cu bal.	1,280	1,500	1,460	1,420
Nickel bronze	88 Cu, 5 Sn, 5 Ni, 2 Zn	1,080	1,220	1,200	1,180
Nickel bronze	30 Ni, 10 Sn, 8 Pb, Cu bal.	1,120	1,340	1,300	1,260
Nickel bronze	40 Ni, 10 Sn, 1 Zn, Cu bal.	1,180	1,400	1,350	1,300
Nickel silver	20 Ni, 15 Zn, 3 Sn, 5 Pb, Cu bal.	1,070	1,350	1,300	1,250
Nickel silver (ingots)	63 Cu, 20 Ni, 17 Zn	1,080	1,250	—	—
Nickel (castings)	1·5 Si, 1·25 Mn, 0·3 C, Ni bal.	1,400	1,590	1,550	1,500
Phosphor bronze	11 Sn, 0·25 P, Cu bal.	990	1,100	1,060	1,020
Phosphor bronze	11 Sn, 0·5 P, Cu bal.	980	1,080	1,050	1,010
Phosphor bronze	11 Sn, 1·0 P, Cu bal.	970	1,070	1,040	1,000
Phosphor bronze (nickel)	11 Sn, 1·0 Ni, 0·5 Zn, 0·05 P, Cu bal.	1,000	1,150	1,110	1,060
Tin bronze	90 Cu, 10 Sn	1,000	1,160	1,120	1,080
Tin bronze	85 Cu, 15 Sn	950	1,100	1,060	1,020
Tin-base bearing metal	89 Sn, 7·5 Sb, 3·5 Cu	360	—	430	—
White metal (sea water)	70 Sn, 1·5 Cu, Zn bal.	—	—	480	—

* Light castings—under ¼ in. in section. Medium castings—¼ in. to 1¼ in. in section (test bars). Large castings—over 1¼ in. in section

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Costing Systems

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—As an ex-German foundryman, being the former proprietor of Berlin's oldest (1874) jobbing iron foundry, who came to this country as a victim of Nazi oppression, and as one who for many years worked for the institution of a proper costing system, I was very interested to learn from your columns that whilst some foundries have established they do not use a costing system for quoting and the problem of establishing prime costs in a proper manner is still exercising the minds of leaders of thought in the British iron foundry industry.

Mr. T. McAlpine has treated this theme in more detail in articles in the JOURNAL of December 14 and 21. Without commenting upon this discussion, I fully agree with the author that there is much more behind determining profits than is at first apparent.

After the Great War, in German iron foundry circles the question of costings was taken up very intensively. Different trials were worked out very carefully and with infinite trouble to help the foundries in this matter. The first effort was the "Harzburger Druckschrift," published in September and November, 1919. Yet amongst other factors, it did not take into sufficient consideration the different variations especially oncost charges operating in every foundry. Later on it was tried to solve the costing problem by introducing minimum prices for all kinds of engineering components in the various industrial branches. For this purpose Germany was divided into four districts West, Central, East, and South. The average price was always taken as the minimum price, determined by the selling prices of about four or five well-managed foundries. Yet these remedies reinforced by further trials did not primarily represent true figures and secondly they were ignored during slumps, becoming through fierce competition the maximum prices, and in practice they were very seldom attained. Finally, after twenty years intense work we believed the right and proper solution was found, but it is too far-reaching to give details here. By a prescribed book-keeping method and charge sheets specially designed for small, medium and large firms, every foundry is now not only in the position to fix the costs properly, but also to state at any time, at least monthly or quarterly, where they stand.

The whole costing report is summarised in a book, which I have lent to Mr. J. G. Pearce, the Director of the Cast Iron Research Association, who kindly is doing the translation for me.

This Report has been since January 1, 1938, the compulsory nationally-unified costing system for all the iron foundries in Germany without any exception. It appears to me as being of importance for the Control during war period and for the urgently needed export trade.

—Yours, etc.,

E. H. SALINGER.

74, Princes Court,
London, W.2.
December 30, 1939

Cupola Operation for Making Alloyed Cast Iron*

Conditions prevailing in different foundries vary so greatly that it is difficult to lay down any hard and fast rules on cupola operation. Economic demands, grade and quantity and weight of castings being produced, type of blower equipment available, design of cupola, facilities for handling molten metal quickly, and many other factors often necessitate some deviation from normal practice. Successful cupola operation depends on adherence to definite principles and a fixed plan of working. Modifications made necessary in the working of individual cupolas may even lead to improved working, if certain rules are observed.

The suggestions given here are based on the assumption that the design of the cupola generally conforms to modern ideas, and that normal quality coke is being used as fuel. Every foundry requires hot, claen, live metal, of uniform temperature and composition, no matter what types of nickel cast iron are being produced and irrespective of the application of class of castings to be cast. In what follows it will be assumed that the lining in the melting zone has already been patched after the previous melt.

Making Up Sand Bottom

The first operation is to make up the sand bottom and the tapping hole. It may appear unnecessary to say anything about these operations, but attention to one or two details will obviate the occurrence of minor troubles. The sand used for making up the bottom should be reasonably dry and not rammed too hard. Wet sand rammed too densely may cause parts of the surface to lift when the bed coke is ignited. A wet bottom will also take longer to dry out and heat up, and thus may have a tendency to reduce the temperature of the metal at the first tap. Another item to control is the depth of the sand bottom. In drop-bottom cupolas (the type most commonly used) the depth should not be too great, as some difficulty may be experienced in dropping the residual contents of the cupola at the end of the blow. In the case of solid-bottom cupolas, firebrick and/or refractory patching material such as ganister is used, and this will only require patching and levelling each day.

Foundries have different ideas on preparing the tap hole. A common fault is to have the tap hole too long. A length of 1½ to 2 in. for the parallel portion is adequate, the hole being tapered away both in front and at the back, at a wide angle. A long narrow tap hole always leads to "freezing up" at some time or other. It is also advisable to have a small saucer-shaped depression on the cupola bottom immediately adjacent to the tap hole, and thus obviate the risk of the first metal to be melted freezing at the inner end of the tap hole. Many foundries have adopted standard-size firebricks or loam sand cores to form the tap hole. This is an excellent practice, but this tap hole block, whether made of firebrick or as a loam sand core, should have the tap hole bevelled from each side.

Weight of Charges

There is a very great deal of variation in the weight of individual metal charges used in cupolas of equal diameter in different foundries. Only too often the weight of the charge is decided without due regard to the efficient operation of the cupola. Careful record and long experience have shown that the size of the coke charge should be determined first and the weight of the metal charge adjusted to suit. The ideal thickness of the layer of melting coke between each charge should be 6 to 8 in., and the weight of the metal charge should vary between 8 and 12 times the weight of the coke layer. The actual weight of a layer of coke 6 or 8 in. deep, for any individual diameter of cupola, will vary with the average size and density of the coke. It may be ascertained quite simply by laying out a circle of bricks of the same diameter as the cupola and weighing the average-size coke required to fill this enclosure to a depth of 6 to 8 in. This will give a basis figure for the weight of each coke split or layer, but it may have to be modified to meet special conditions. For example, in very small cupolas the depth may have to be increased, but for cupolas lined to 30 in. and over, the above method will give a reliable guide.

For good-class grey iron mixtures consisting entirely of pig-iron and scrap, it is best to commence with a ratio of 10 parts of iron to 1 part of coke by weight. In some types of cupolas of modern design this figure may be considerably exceeded, with resulting economy in fuel. When steel scrap is incorporated in the mixture in considerable proportions it is advisable to reduce the weight of metal in each charge and keep the weight of melting coke constant. When melting large quantities of steel scrap, the chief reason for recommending less weight in a cupola charge is to ensure that sufficient coke is left to replenish the coke bed after the steel has absorbed carbon from the fuel.

The examples in Table I of weight of charges for different types of mixtures in cupolas lined to 36 in. and 48 in. internal diameter will give some indication of what is considered suitable, but conditions of operation and cupola design may make it necessary to use larger or smaller charges. For instance, in making up comparatively small amounts of nickel alloy cast iron, for the purpose of obtaining uniformity of composition, it may be advisable to use smaller charges. If approximately 20 cwts. of special iron are required from a 48-in. cupola, it would be better to use three 7-cwt. charges (21 cwts.) and to collect the three charges in one ladle, rather than two 10-cwt. charges.

TABLE I.—*Examples of Coke and Iron Charges for Cupolas Based on Optimum Depth of Each Coke Charge.*

Cupola diameter	36 in.	48 in.
Coke charges ..	56 lbs.	112 lbs.
Metal charges—		
No steel ..	5 cwts.	10 cwts.
25 per cent. steel scrap ..	4½ „	9 „
60 per cent. steel scrap ..	4 „	9 „

Height of Coke Bed

A very important factor in cupola operation is the height of coke bed. A high coke bed is an essential if hot metal is to be obtained right from the first tap. Although for ordinary non-steel mixtures coke beds of 18 to 24 in. above the tuyeres are often used, it is normally found that the first ton or so of metal is dull and deficient in life due to a very low degree of superheat.

For base irons to which nickel and nickel-chromium additions are to be made, high initial temperatures give smoother working, easier handling of the molten metal, and better castability. Consequently it is advisable, when this type of material is being melted as the earlier charges in a melt, to provide a coke bed at least 30 in. above the tuyeres, and when high percentages of steel scrap are used in the production of high-strength cast iron, 40 to 48 in. is not excessive.

Igniting the Coke Bed

First of all a wood and soft coke fire is started on the bottom, and when this is well alight the coke bed is gradually added over a period of time. The natural draught induced by the stack is usually sufficient to get this alight. When the back is made up, the tuyeres are left open, and the coke bed made to its final height. Where a high percentage of steel scrap is charged, the bed should be blown up for a few minutes, with a very low blast pressure. Any part which has burned away must be made good to the predetermined height. The cupola is then charged to the level of the charging door.

Soaking Period

After the stack is completely charged up to the charging door, a soaking period of at least one hour should be allowed. Leaving the tuyere peep holes open will maintain the coke incandescent and a slow rising column of hot gas will preheat the first charges and thus aid in increasing the temperature of the metal in the first tap.

Order of Charging

When there is no steel in the charge, pig-irons and scrap may be charged one on top of the other or mixed together. It is advisable to endeavour to have material of a reasonably regular size for a particular diameter of cupola. Very large lumps should be avoided. Where alloys such as "F" nickel ingot, ferro-chromium, ferro-manganese and ferro-silicon are constituents of the mixture, these should be placed in the centre of each charge, and care should be taken to keep them as far as possible in the centre axis and away from the cupola wall.

Where 20 per cent. or more steel scrap is charged, the following order of charging has been found to give good results:—(1) Pig-iron on coke; (2) foundry returns or remelt and scrap; (3) nickel and ferro-alloys; and (4) steel scrap. It has been found that if the pig-iron or foundry returns melt and accumulate first, the resulting metal contains sufficient silicon and manganese to ensure deoxidation of the remainder of the charge as it melts. Also, when steel comes down last, it remains in contact with hot coke a shorter period of time than if otherwise melted, and less carbon is absorbed.

Tapping and Collection of Metal

Where alloy cast iron or base metal for alloy ladle additions must form the first part of the melt, it is essential to preheat the ladle thoroughly. Alloy cast iron and base metal for alloying in the ladle should be collected as far as possible in multiples of two or more charges to ensure uniformity of composition.

When steel-mix cast iron of low total-carbon content is being produced, the metal should not be left in the well for too long a period. Therefore, it is good practice when low total carbon is required to collect a number of smaller taps in the same ladle, and thus reduce the period when the molten metal picks up carbon from contact with the bed coke.

Slagging the Cupola

When the cupola has been in operation for some time, a considerable volume of slag will have accumulated and must be slagged off by opening the slag hole when the metal level is high. By judging the correct time with metal and slag well up, it is possible to tap a hot body of fluid slag which will flow freely. A small amount of slag should always be left, as it forms an excellent protective covering for the metal in the well. Consequently the slag hole should be closed before the molten metal reaches that level.

* Communication from the Research and Development Department of the Mond Nickel Company, Limited.

Acid Electric Furnace Practice*

By WERNER FINSTER

(Slightly Abridged.)

Of the some 265 foundries in the United States which in 1937 were engaged in the manufacture of steel castings, 175 used the electric melting process for part or, in most cases, for the total of their production. Data compiled by the Steel Founders' Society of America listed 264 electric furnaces of the direct arc type and 18 induction furnaces in the steel casting industry.

Considering that the development and application of the electric melting process falls only in the beginning of the present century, its advancement is remarkable. Its rapid growth in the steel casting industry is largely due to the flexibility which it offers and which suits the needs of an industry the products of which have often to meet specifications of various chemical and physical requirements in small tonnage quantities. It is therefore not surprising that the electric melting process prevails in those foundries with a monthly production of castings of 750 tons or less. Nearly 50 per cent. of all furnaces installed in America are of the 1½- and 3-ton sizes and most of the arc furnaces are of the 3-phase a.c. type, equipped with automatic electrode control and can be tilted. There are several designs on the market, each with special features, too numerous to cover in this Paper.

The majority of the arc furnaces for steel-foundry use are acid lined. While the acid process permits no control over sulphur and phosphorus and therefore demands raw materials low in these two elements, there is a sufficient supply of basic scrap in most localities available to make this no serious handicap, even at a price extra. Reasons for the preference of the acid process in the foundry are:

(1) Lower refractory cost due to lower cost of the lining material itself and to the longer life of the lining material.

(2) Lower power consumption, especially when compared with a two-slag basic process.

(3) Greater tonnage output per unit time for a given charge.

(4) Slag of higher viscosity, which is an important consideration, as in many foundries making small castings the moulds have to be poured from hand shanks.

(5) Greater fluidity of the metal, permitting the casting of thinner sections with greater assurance of having all corners and details clearly reproduced.

In describing acid electric melting practice, an attempt will be made to cover the subject in a general rather than a specific way and to point out known variations in melting methods.

Where definite data are given, they refer to the practice in use at the foundry with which the writer is connected. The furnace used is a 3-ton Moore Lectromelt with lifting and swinging roof and a standard charge of 8,000 lbs.

Furnace

Bottom.—The so-called lifetime bottom often consists of two layers of brick, either clay or silica, on which the bottom is rammed or sintered. Either silica sand or ganister is used as base for bottom material and great variations in mixtures exist. Fireclay, pitch, glutrin or molasses water are mixed with the base material, thoroughly mulled in the sand muller and, where ramming is applied, rammed into place with a foundry pneumatc rammer. Practice appears to favour rammed-in bottoms.

Side Walls.—Side walls are either built of silica brick or are rammed in, using the same mixtures as for the bottom. When the side walls are built of brick and built up from the lifetime bottom, the rammed or sintered in bottom is brought up above the slag line of the side walls.

Roof.—Silica brick is used for the roof in most cases, either in form of standard bricks or special shapes. Monolithic roof linings have been tried recently on some furnaces and apparently have shown promise, at least on small-sized furnaces. During periods of greatly curtailed operations and intermittent melting schedules, clay roofs have been advantageous. For obtaining the best performance from clay roofs, it is advisable to raise the roof several inches to compensate for the lower refractoriness.

Door Linings.—For the lining of doors, as they have to withstand great thermal shock, either monolithic or clay linings are preferable.

Refractory Life

The life of a lining and roof may vary within wide limits, as it depends on many factors. Foremost of all is the care used in their installation and maintenance. Operating conditions have a great bearing, intermittent operations shortening the life. Another factor is the size of charge used. Most electric furnaces are charged above their rated capacity, which means either carrying a thinner lining or bringing the bath level closer to the roof, unless the latter has been raised.

When charging 5 tons per heat the average on five linings and roofs was 900 tons per roof and lining, whereas charging 4 tons per heat the life of the roof increased to 1,000 tons per roof and for the lining to 1,200 tons.

Overcharging the furnace has not only a bearing on the life of the lining, but also may influence the quality of the steel, as has been shown by John H. Hruska's investigation* on the reaction ratio—the quotient of the bath area and the weight of metal—for different types of melting processes. For a 3-ton furnace, carrying 13-in. side walls and a 12-in. ganister-base bottom rammed on top of the two-layer clay brick lifetime bottom with the rammed mixture feathering off above the slag line, the inside diameter at the slag line is about 77 in., giving an area of 4,653.5 sq. in. Using Hruska's formula

$$\text{Reaction ratio} = \frac{\text{Bath area in square inches } (A).}{\text{Weight of metal in pounds } (Wt.)}$$

the reaction ratio for a 6,000-lb. charge or rated capacity is 0.776, for an 8,000-lb. charge 0.582, and for a 10,000-lb. charge 0.465. A decrease in reaction ratio should be compensated by increasing the intensity of the boil, or prolonging the boil. However, there are practical limitations to the extent to which this compensation can be carried. It once happened that the charge was as high as 14,000 lbs. for pouring large non-specification castings, and the quality of the steel from these heats certainly showed the effect of the low reaction ratio.

Electrodes

Both carbon and graphite electrodes are used. The choice has been a question among operators for years and apparently still is, and, from what information the author could gain, the ratio is about 50:50. The consumption per ton charged varies between 10 to 22 lb. for carbon electrodes and 5 to 15 lb. for graphite electrodes and is greatly influenced by the rate of production, type of steel made, and such special melting practices as raising the carbon content of the bath for higher carbon analysis specifications by dipping the electrodes. Using a 10-in. carbon electrode the average at the author's works for the last two years was 11 lb. per ton charged.

Power Input

Most furnace installations have transformers with a number of taps for varying arc voltage. Generally two taps are used, a high tap for melting down and a low tap for the refining operation, though some installations have also an intermediate tap available.

Selection of Raw Materials

In the selection of raw materials, price, local conditions in regard to easy access to certain types of scrap, chemical and physical balancing of charge make-up and charging facilities are the deciding factors. Depending on the type and size of castings made in a given foundry, the base of the charge may be from 30 to 50 per cent. foundry returns, heads, gates and risers. This does not imply that higher percentages of foundry returns cannot be used. Charges of 100 per cent. foundry scrap have been melted successfully provided due consideration was given to the higher silicon content of the charge in working the heat. Punchings, forgings, plate, stampings, turnings, bundles and railway scrap may make up the balance of the charge. Most foundries to-day analyse all their incoming raw materials, and with the increasingly rigid requirements in regard to limitations on incidental alloys, especially for welding-grade castings, proper selection of raw materials has gained force. This applies particularly to the electric steel foundries, many of which furnish regularly from 5 to 15 types of standard alloy steels.

Separation of alloy heads and gates from carbon steel returns is not only profitable but essential. Unless the melting department knows the approximate composition of its charge, uniform results can hardly be expected, especially when, as in most acid electric steel foundries, the melter has to judge the carbon content of his preliminary tests by the grain of the fracture. In the author's foundry all alloy heads and gates and castings are painted according to a colour scheme which, while it does not take care of all alloy combinations, at least indicates the alloy groups. This method helps not only the melting department, but also facilitates the proper handling of alloy steel castings through the various finishing operations. In the charging operation itself care must be taken that the charge is dense enough to maintain the arc when the power is turned on, that the hearth underneath the electrodes is well covered and that heavy scrap is not placed on top of the charge, to avoid breakage of the electrodes. The great advantage of a top charge operation is, apart from the saving in charging time and labour, that the charge can be made up in a drop-bottom charging bucket in a predetermined manner and placed in the furnace accordingly.

Melting Practice

Fundamentally, acid electric furnace practice does not differ from the other processes of steel-making covered in the present symposium. Sims has dealt with the fundamentals in an excellent contribution before the American Foundrymen's Association in the 1934 "Symposium on Porosity,"* and Batty has given a clear cut and concise description in his Paper, "The Making of Acid Electric Steel for Castings."† All that will be attempted in this Paper is to emphasise some of the special problems encountered in acid electric furnace practice. As in other cold-melting processes there are three distinct periods to consider: (1) melt down, (2) refining and (3) finishing of the heat.

* Paper presented at the 43rd Annual American Foundrymen's Association Convention, as part of the Steel Melting Symposium. The author is metallurgist with the Reading (Pa.) Steel Casting Division of the American Chain & Cable Company.

* Hruska, J. H., "Mass Effect and Quality in Steel Making," "Iron Age," April 12, 1934, p. 14.

* Sims, C. E., "Preparation of Steel to Avoid Porosity in Castings," Trans. A.F.A., vol. 42, 1934, pp. 323-338.

† "Metals Handbook," A.S.M., 1936 edition, pp. 636-641.

During the melt down, partial oxidation of the charge occurs. The basic oxides, MnO and FeO, form with the oxidised silicon from the charge and the sand adherent to the foundry returns a highly oxidising slag. If insufficient silica be available from the charge itself the lining will be attacked. Any delays during the melt-down period, such as breakage of electrodes, bridging of charge or putting-on of new electrodes, will increase the amount of oxidation and tend to have the charge melt down "soft." The same will be noted on a cold furnace, also if the material in the charge is thin and bulky or the scrap very rusty.

Refining

As soon as the charge is melted and under a slag cover, the refining period begins. Knowledge as to what constitutes refining has been greatly enlarged by the results of many extensive investigations published in recent years. Dealing with an expensive fuel and having a fast heat input at one's command, the temptation to melt down, bring the bath to pouring temperature, deoxidise and tap is ever present, and the quality of many heats has been sacrificed in the attempt to increase the tonnage output per time unit.

The importance of the boil in regard to gases other than oxygen, the influence of temperature on the solubility of these gases and the interrelationship of oxide content of slag to oxide content of the bath are better understood to-day and the knowledge gained has been widely applied in acid electric steel foundry practice. Refining practices used to-day can be roughly divided into two groups. In discussing the two practices it is assumed that a normal carbon steel of Grade B type is being made.

In the first group the charge is melted down at 0.30 per cent. carbon or higher. Sufficient iron ore or mill scale is then added to boil the heat to a point low enough in carbon so that when the final additions are made, the heat will finish within the desired carbon range. In this practice, the boil is often first stopped by additions of ferro-manganese, ferro-silicon, silico-manganese, either singly or in combinations, before the final additions of manganese and silicon are made, or the deoxidisers are added as soon as the desired carbon has been reached.

In the other group, the charge is generally melted down to a lower figure, about 0.20 to 0.25 per cent. carbon, though as high as 0.40 per cent. carbon has been reported, and sufficient ore added to carry the carbon elimination to about 0.10 per cent. carbon or even lower. Due to the high FeO content of the bath at this low carbon content, the bath is then partially deoxidised and recarburised by either low-silicon pig-iron or American washed iron and then finished by making the final ferro-manganese and ferro-silicon additions.

Heat Input

Before pointing out the advantages of each practice one assumption has to be made—that both groups are regulating their heat input in such manner that a low residual silicon and manganese content has been obtained in the bath prior to the final additions. The importance of a low residual silicon and manganese content in the bath prior to deoxidation has been pointed out by Sims and Batty and has become recognised by many acid electric operators. Inasmuch as silicon and manganese can be oxidised at lower temperatures than carbon, their residual content can be low before the carbon boil takes place to any extent.

Based on the above assumption, the advantage of the first melting practice is that it is cheaper. Less power input is needed and the electrode consumption will be lower, no recarburiser has to be used and the lining and roof life of the furnace will be longer. However, as the slag under this practice will be lower in FeO content, the danger of silicon reduction toward the end of the heat increases.

The advantage of the second practice is that due to the high FeO content of the bath at the end of the boil, the amount of gases other than oxygen will be much less than with the first practice and that by eliminating nearly all the silicon and most of the manganese a uniform base metal is obtained from which the final additions can be calculated more closely. Its disadvantage is the higher cost.

It is realised that an attempt to classify existing melting practices into two groups is a broad generalisation when probably no two plants use identically the same practice. Variations not only exist in the analysis of the charge, at the melt-down and at the end of the boil, but also in the manner and amount of ore and mill scale additions, of adding the final additions to bath or ladle, of recarburising, and adding the silicon. One of the greatest variables exists in the heat input. The arc voltages used vary over a wide range, though it appears to be generally accepted practice to switch to lower voltage when the charge has been melted and the refining period begins.

The heat input should be so regulated that the proper tapping temperature of the bath is reached prior to the addition of the final deoxidisers. Once the final additions have been made to the bath, just sufficient time should be allowed for the deoxidisers to melt and diffuse throughout the bath. Rabbling the heat at this stage will speed up the reactions. Raising the temperature after deoxidation or even maintaining a moderate power input for a prolonged period of time tends to cause silicon reduction, especially if the slag is viscous.

Care in Tapping

In tapping, care should be taken to prevent the slag from entering the ladle with the metal. In the author's practice, a 6-in. tap hole is used which together with the spout is rebuilt after each heat and carefully dried. In tapping, the furnace is rolled over quickly to hold the slag back. Other means which are successfully used are either skimming spouts or the insertion of a burlap bag into the tap hole which is only removed after the furnace has been tilted sufficiently to bring the slag level above the tap hole.

In discussing the refining period, low residual silicon and manganese in the bath and a prolonged boil and judicious power input have been stressed. Beyond this no other general recommendations as to which practice to follow can be made. The choice depends entirely on the preference and experience of the melting and metallurgical staffs at each plant, on the make-up of the charge and not the least on the type of castings to be poured and the prevailing mould conditions.

Temperature and fluidity of the metal are judged by spoon tests, timing the rate of film formation or by observing the behaviour of the metal when slowly poured from the spoon. Special fluidity test moulds are used in some foundries. Progress in the refining process is also observed by the changes in the slag.

Slag Practice

In spite of the large number of acid electric furnaces in the steel foundry industry few comparable data are available on the effect of various slag practices on the quality and economy of the respective steelmaking methods. This does not mean that the slag-metal interrelationship has been given little attention in acid electric foundries, but is due rather to great variations in slag-making practices and to a lack of standardised test methods to evaluate the effect of varying slag compositions on the working of the heat.

Generally speaking, acid electric steelmaking is a one-slag process though some operators do skim off the melting slag or pour off part of it and proceed by building up a refining slag. Some operators let the furnace make its own slag, stating that by doing so the slag volume can be held to a minimum and that a higher manganese yield can be obtained from the final additions. Others add sand to protect the furnace refractories from the attack by the basic oxides formed; others decrease the FeO content of the slag by lime or limestone additions; while others add old ladle slag with the charge to increase the MnO content of the slag in the early stages of the heat.

With such variety of practice no average figures can be given. Melting slags will average FeO 35 to 40 per cent.; MnO 10 to 15 per cent.; SiO_2 50 to 55 per cent. Final slags in practices where no lime is added will average FeO 15 to 20 per cent.; MnO 15 to 25 per cent.; SiO_2 57 to 62 per cent. Where lime is used, the CaO content generally is held between 4 and 8 per cent. and the FeO content of the final slag runs somewhat lower; about 13 to 15 per cent. Considerable interest exists at present in certain districts as to the influence of slag practice on the working of the heat and the resultant properties of the metal and as the investigation will be based on a common method of testing, comparable information should be gained. At present, the inclined plane method and the pancake method are most commonly used.

Silicon Reduction

Reference has been made repeatedly to silicon reduction. Batty and Melmoth were the first to note the influence of an "over reduced" condition on the fluidity of steel. While silicon reduction is not confined to acid electric furnace practice and can occur in acid open-hearth practice as well,* the higher temperatures employed in acid electric melting, the possibility of using more viscous slags at these high temperatures, and the high concentration of heat input under the electrodes, all favour reduction of silicon from the slag. As Batty has pointed out, an addition of iron ore to the bath or slag will correct this condition, which has also been termed "under-oxidised." This should be borne in mind when discussing silicon reduction from the slag. It is standard practice in some foundries to reduce all the silicon from the slag and not to add any silicon at all in form of ferro-silicon. The silicon reduction referred to in this Paper is only the unintentional reduction of silicon from the slag, especially after the final deoxidisers have been added which can be best prevented by shutting off the power entirely as soon as the final deoxidisers have been added to the bath.

Special Deoxidisers

Apart from the deoxidisers commonly used in all steelmaking processes, *i.e.*, ferro-manganese, ferro-silicon or silico-manganese, special deoxidisers are generally used in an acid electric practice. To avoid misconceptions it should be emphasised that this is not due to the acid electric process itself, but to the condition under which it is used. As was pointed out earlier, preference for acid electric steel melting is given by those foundries which have monthly productions of less than 750 tons, and in most cases less than 300 tons. Many small and/or intricate castings are handled in these foundries, but few tonnage jobs. Green-sand practice prevails in acid electric foundries. Casting many small jobs from a heat demands higher pouring and higher tapping temperatures. Most acid electric heats are tapped above 1,650 deg. C., and many small castings are poured around 1,650 deg. C.

Work of many investigators has shown that

* Herasymenko, P., and Valenta, E., "Some Problems of the Physical Chemistry of Steel Making," Trans. A.F.A. Vol. 42 .1934. p. 30.

the solubility of gases increases with increasing temperatures. Sims states: "Although not offered as a positive conclusion, it seems logical to regard all 'dead' or 'killed' steels at their freezing point as containing gases in varying degrees of supersaturation. These gases under favourable conditions will be retained in solid solution, but are potentially capable of causing porosity." In pouring small green-sand castings, the high tapping and pouring temperatures, triple exposure of the deoxidised metal to re-oxidation—while tapping from furnace into bull ladle, transferring from bull ladle into handshank and from handshank into mould—each transfer accompanied by an increase in surface exposure, and the mould conditions themselves all work against a favourable condition. It has been a problem that has taxed the ingenuity of all those connected with the production of castings under the described conditions, and the success with which it has been solved is best demonstrated by the large tonnage of high quality castings produced.

A great variety of special deoxidisers have been tried and have been successfully used under certain conditions. Aluminium has been used more generally than any other special deoxidiser; its effect is a subject in itself and has been covered often and to great length. Thanks to the research work of Comstock, Sims and Lillieqvist and the recent work of Sims and Dahle, the mechanism of its action has been explained, and many hundred heats have been made during the past year with uniform physical properties in foundries which prior to Sims and Dahle's excellent work had experienced the erratic results often discussed. Whether the special deoxidisers are added to bath or ladle, great and continuous care should be exercised in the manner of adding, for only in this way can consistently good results be expected.

Operating Data

From the foregoing description of acid electric furnace practice, it can be concluded that data on furnace operations will vary within wide limits. The size of melting unit, type and make up of charge, type of melting procedure adopted, specification requirements and mould conditions greatly influence the ton per hour production rate. Where local conditions are such that the energy input is subject to demand charges it often pays to prolong the melting down period. Therefore, no data can be given that would approximate average operating conditions for the industry, nor would such data be of much value in comparing the melting processes dealt with in this symposium.

(*Continued from column* 2.)

with most of the other practical sciences must apparently be ultimately reduced to a branch of applied physics in the more general sense.

An analysis of this highly compressed work does naturally bring out points of difference in treatment between the author and the reviewer, but this is inevitable and in no way detracts from the value of the work in providing a closer understanding of the principles of optical metallurgy. Any reference to such differences are therefore irrelevant. A reasonable groundwork of the theory of light is, however, necessary if the reader is to find the book as useful as it should be, especially in view of the rapid recent advances made in the theory of the nature and properties of light. It is unfortunate that the dissemination of knowledge must be made at the relatively high price of 14s. for a book consisting of 176 pages.

E. R. F.

Book Review

The Physical Examination of Metals. By Bruce Chalmers, Ph.D., F.Inst.P. Published by Edward Arnold & Company, 41 and 43, Maddox Street, London, W.1. Price 14s. net.

This book is the first volume—"Optical Methods"—of a pair planned to cover a brief and selective survey of the applications of physical methods to the examination and study of metals. The second volume, in preparation by Dr. Chalmers in collaboration with Dr. A. G. Quarrell, will deal with other branches of physics as applied to the investigation of metals. The object of the work is disclosed in the author's preface, which points out that while certain physical methods of examining metals have become such an ordinary part of the metallurgist's technique that they have come to be regarded as metallurgical rather than physical methods, "a number of physicists have been investigating various properties of metals by methods which are virtually unknown to those metallurgists who have not had special training in physics. Such methods are often looked upon with suspicion or ignored by metallurgists simply because they are not understood. The object of this book is to explain, in as simple language as possible, the physical theory underlying these methods, to describe the more important applications that have been made, and, where possible, to describe the technique so that the reader can apply it himself. In some instances it is not deemed practicable to describe the technique in detail because specialised training is required for its application. Such methods are included, however, because a general understanding of them leads to a better appreciation of the value and limitations of the results."

This, the first volume, is limited, as stated, to optical methods of examination, and contains chapters on geometrical optics, on wave optics subdivided into interference and diffraction, on polarised light and sources of light. The general treatment is of the semi-essay and semi-textbook style, which is very readable. No attempt at completion is claimed or made, while references to the original work have been cut to the bone. Nevertheless, it is difficult to escape the feeling in some parts that a chapter or section thereof has been compounded by stringing together quite good summaries of the work of different investigators dealing with more or less the same aspect of research. The gaps are, of course, due to the absence of a co-ordinated attack on a specific problem on a sufficiently comprehensive basis. The general drawback of the application of physics to any of the less developed analytical sciences is this host of sporadic attacks on different fronts, leaving many unexplored problems which have for the time being not attracted the curiosity of research workers or the solution of which has not been an industrial or economic necessity.

Considering the vast amount of research which has been conducted on the applications of optical physics to metallurgy and its relative lack of co-ordination, Dr. Chalmers has set himself a formidable task by not merely sifting and classifying the principal work which has been done—which left in this stage would have given us a voluminous tome of thousands of references, itself out of date before publication—but also by going a stage farther and reducing the subject matter to its irreducible essentials, and presenting the metallurgist, whether of long experience or still in the chrysalis research stage of post-graduateship, with a succinct survey of the elements of the subject covered by the book. From this point of view, Dr. Chalmers has rendered all metallurgists and physicists a service, especially as metallurgy in company

(*Continued at foot of previous column.*)

Commercial Coppers Reclassified

Readers interested in the copper industry will have noticed that in the recently-issued Control of Non-Ferrous Metals (No. 5) Order, 1939, a new and perhaps rather unfamiliar classification of commercial copper has been included, which is briefly as follows:—

(1) High-conductivity electrolytic copper.
(2) Fire-refined copper sold or intended to be sold as high-conductivity copper.
(3) High-grade fire-refined copper.
(4) Fire-refined copper of ordinary quality containing not less than 99.7 per cent. of copper.
(5) Fire-refined copper containing not less than 99.2 per cent. of copper.
(6) Black hot-rolled copper wire rods.

No doubt this classification will be criticised; nevertheless it shows evidence of a praiseworthy attempt to place the grading of copper on a more logical and scientific basis than hitherto. It will be noted that such obsolete and ill-defined terms as "best select," "fine," "tough," etc., are absent.

On the other hand, the view may be taken that the new classification does not go far enough, and is neither as complete nor as definite as it might be, but presumably it is a compromise based on many conflicting factors which have had to be taken into account to meet the present abnormal state of affairs and to interfere as little as possible with established commercial practice. It will also be appreciated that under the present circumstances sources of supply are necessarily limited, and that certain brands of metal may no longer be available. Little difficulty should be experienced, however, in obtaining suitable substitutes from sources within the Empire.

Explanation of Grade 3

Copper of grades (1) and (2) in the classification will conform to the recognised standards for high-conductivity metal, and these grades as well as grades (4) (5) and (6) do not call for any particular comment. In the case of grade (3), however, it will be noted that no details are given of what the term "high-grade fire-refined copper" is intended to cover, but it is evident that it is designed to include that large category of first-quality fire-refined copper, much of which has in the past originated from Chilean and, more recently, African sources, of which such brands as C.F.R., Braden, M.T.D., B.C.R., and E.R.M. are examples. In nearly all cases the minimum copper content of this grade would be approximately the same as that of the high-conductivity grades (*i.e.*, about 99.88 per cent.), although the metal might not always be suitable for electrical purposes requiring the highest conductivity.

While the new classification is based primarily on conductivity and copper content, and indirectly on impurities, provision has been made to include also certain categories of copper containing very small amounts of specified constituents, such as arsenic, cadmium, etc. For the purpose of classification the specified constituents are to be counted as copper. Thus, for instance, arsenical copper containing over 99.3 per cent. copper and nominally 0.4 per cent. arsenic would be classed not as grade (5), but as either arsenical grade (3) or (4), according to its combined copper and arsenic content.

The need for a more rational classification of copper has long been recognised among progressive producers and users of the metal, and, although the new grading may not be ideal for adoption in all future circumstances without amplification or adjustment, it should be welcomed as the foundation upon which a better and more logical order of things in the copper industry can be established.

Influence of Climatic Conditions on Enamelling*

By DR. BERTHOLD DEUTSCH

The object of this Paper is to show the influence of changing temperature and humidity in the atmosphere, caused by climatic condition, on the various processes carried out during the manufacture of enamelled products.

It is true that the influence of atmospheric conditions on enamelling is not as important as in some other industries, as, for instance, in the textile and tobacco trades, where the maintenance of constant temperature and humidity, independent of the changing condition in the atmosphere, is of fundamental importance. There is no doubt that the variation of temperature and humidity of the air, due to the weather, has a definite influence on the enamelling process, and especially where extremes, such as a heat wave or pronounced dry, wet or cold periods, are encountered, or, with a sudden change of weather, conditions may be established which cause serious difficulties during the enamelling process.

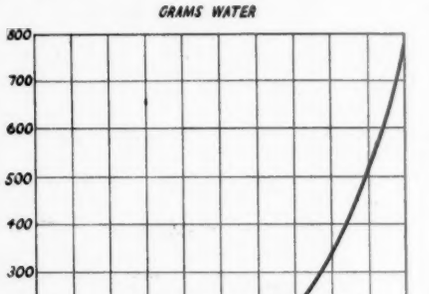


FIG. 1.—RELATION BETWEEN TEMPERATURE AND HUMIDITY (GRAMS PER CUB. METRE).

It is clear that the average figures for temperature and humidity and the amount of variation during any period depend on the geographical position, the season and, more or less, on local influence.

Humidity

Air always contains a varying amount of water in vapour form, commonly called "humidity." The amount of water vapour which can be carried by the air up to the point of saturation depends on the temperature. This amount increases with increasing temperature, and is called absolute humidity of the air. The figure for the actual amount of water vapour present in the atmosphere at a certain temperature is expressed as a percentage of the absolute humidity and is called relative humidity. Fig. 1 shows the relation between temperature and humidity. The influence of temperature on the saturation, particularly at a higher temperature, is remarkable.

The humidity and temperature figures for any district depend largely on climatic conditions, and Fig. 2 shows variations in these figures during a year at two different places in Europe —one situated near the coast (East Prussia), the other near Basle in Switzerland. The average temperature figures are nearly the same, but the maritime influence on increased humidity is clearly shown. Fig. 3 shows the condition in Vienna during 1935 and 1936. These two examples demonstrate that the variation of the average figures of temperature and humidity during a year is quite remarkable. The variation of the temperature and humidity is considerably greater during 24 hours when a sudden change of weather occurs.

How far, then, is the enamelling process influenced by extreme or changing conditions of temperature and humidity, and which parts are mostly affected?

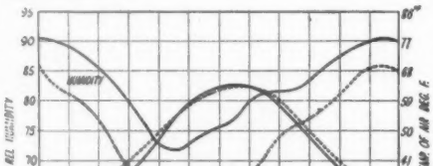


FIG. 2.—VARIATIONS IN HUMIDITY AND TEMPERATURE DURING A YEAR IN EAST PRUSSIA AND AT BASLE.

Though the influence of humidity and temperature on the raw materials of enamelling—steel sheet or cast iron, and the raw materials for frit making—is not taken in consideration in this Paper, the processes mainly affected by the climatic condition include pickling, milling, ageing, the application of the enamel slip, the drying and firing processes.

Pickling

Pickling in its widest aspect in enamel plants consists of degreasing, pickling in sulphuric or hydrochloric acid, rinsing, neutralising and drying. Of these, pickling in hydrochloric acid may be profoundly affected by temperature variation. Pickling in sulphuric acid is carried out "hot" in a bath containing 6 per cent. actual acid. The usual temperature is about 150 deg. Fah., and the temperature and concentration are strictly controlled in order to maintain proper working conditions. Pickling with hydrochloric acid is carried out "cold," the usual acid strength being about 11 per cent. The temperature of the acid will be more or less the same as the temperature of the shop (65 to 68 deg. Fah.).

In order to show the influence of changing temperature in the pickling process, the fundamental principals of pickling may be recapitulated. To remove rust and scale from the metal the ware is pickled in an acid solution. The acid dissolves the rust and attacks the iron, producing hydrogen gas, which forces the scale off the metal surface. The most important part of the pickling process is the removal of this scale from the metal. The whole pickling process may be explained by the following equations:

(i) $Fe_2O_3 + 6\ HCl = 2\ FeCl_3 + 3\ H_2O$.

(ii) $Fe + 2\ HCl = FeCl_2 + H_2$.

(iii) $2\ FeCl_3 + 2H = 2FeCl_2 + 2HCl$.

Equation (i) shows the reaction between scale and acid, equation (ii) the attack on the bare iron, and (iii) the reaction which takes place beween the ferric chloride which has been formed and the hydrogen gas, thus transforming the yellow ferric chloride into the green ferrous chloride. This process makes it impossible to use old hydrochloric pickle solution as a raw material for iron oxide colours, because these oxides are based on ferric salts (ferric oxide). The rate of the acid attack on the iron is largely determined by the hydrogen-ion concentration, which again depends upon the kind of acid, its temperature and concentration. Hydrochloric acid ionises almost completely when present in quite high concentration, and forms very mobile solution even when cold. At a given concentration of hydrochloric acid, the rate and speed of pickling will depend largely on the temperature of the acid. A few experiments which can be carried out without any special equipment will show the influence of the bath temperature on the pickling rate.

Small 20-gauge sheet-iron plates, 4 in. square, were carefully cleaned to remove grease and dirt, then dried and weighed. They were then pickled for a period of 10, 20, 30 and 40 min. in 6 and 12 per cent. hydrochloric acid at a temperature of 41, 59, and 86 deg. Fah. After pickling, the sheets were rinsed in water, dried and washed in alcohol to remove any moisture, and then re-weighed. The loss of weight was a measure of the acid attack.

Fig. 4 shows the result of these experiments, and it is easy to realise that the influence of temperature is very significant. Assuming that at a temperature of 59 deg. Fah. and with a 12 per cent. acid the sheet would be perfectly pickled with a loss of weight of 0.30 grams, this will be achieved with a pickling time of 18 min. In order to secure the same effect at 41 deg. Fah. the time will be about 26 min., and at 86 deg. Fah. about 13 min. Therefore, it is obvious that weather conditions which will influence the room temperature considerably and change the usual pickling temperature, at least will cause wide variation in the working speed and output of the pickle room. The usual control in a pickle room using hydrochloric acid includes the control of the acid strength and the concentration of iron salts, but the temperature of the pickle bath is only rarely controlled.

A very serious lowering of the acid temperature will soon be evident by increased pickling time, sometimes associated with underpickling, resulting in poor adherence of the ground coat and delayed fish scaling. An increased pickling temperature will reduce the pickling time, but will increase the formation of gas bubbles and may induce "overpickling," *i.e.*, the sheets will have a "patchy" and rougher surface, so preventing the even draining of the ground coat.

* A Paper read before the London Section of the Institute of Vitreous Enamellers, Mr. W. Thomas presiding.

Moreover, overpickling may be the cause of blisters and boiling of the ground coat.

Recent investigations have proved that the absorption of hydrogen by the iron during pickling is one of the main reasons for the development of serious troubles during the further stages of enamelling. The appearance of serious blistering, boiling and reboiling and of a certain kind of fish scaling are regarded as a result of absorbed hydrogen in the iron.

Hydrogen Absorption

The hydrogen formed during pickling (equation (ii) shows its mechanism) consists, at the moment of formation, of atoms only, and has the ability, even at room temperature, to penetrate the iron and pass through it. Hydrogen is soluble in iron and can pass through it only so long as it is present in its atomic form, but as soon as two atoms form a molecule (and this may easily happen when the gas on its passage through the iron encounters a small cavity or a non-metallic inclusion) the gas is insoluble in iron and can no longer pass through it. When hydrogen in its molecular form has been formed in the iron and more hydrogen in atomic form is developed by pickling and passes through the iron, the amount of hydrogen gas already existent may be considerably increased.

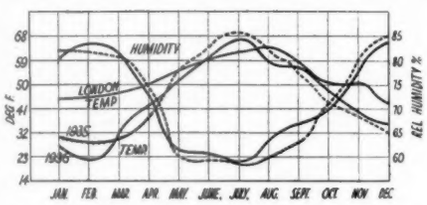


FIG. 3.—VARIATIONS IN TEMPERATURE AND HUMIDITY IN VIENNA DURING 1935 AND 1936.

These local accumulations of hydrogen cause an increase of the pressure existing in the iron and the increased temperature during the burning may increase this pressure to a few hundred atmospheres. Even a small amount of hydrogen in the iron may produce difficulties when, after repeated firing operations (as is the case with sign work) the pressure will rise sufficiently to produce blistering.

The amount of hydrogen passing through the iron and the speed of penetration depend upon various factors. The composition of the iron and its structure, the thickness of the metal and the properties of the acid (including the kind of acid, its strength, temperature, and the amount of type of impurities) are all factors of importance.

The kind of defect—blisters, boiling, reboiling or fish scaling—which may arise, depends upon the amount and locality of the increased pressure and at what period during the enamelling process the maximum of pressure is exerted. Edwards has published figures* as to the influence of the temperature and acid strength on the penetration of hydrogen and its passage through the iron. He gave data as to the time required to allow 4 cub. cm. of hydrogen to pass through a 0.125-mm. (1/200-in.) thick sheet at varying temperatures. Some of these results are set out in Table I.

Table I stresses that the amount of hydrogen which passes through the iron is rapidly increased at higher temperatures, and therefore the possibility of defects due to hydrogen entrapped in the iron is more probable with increasing pickling-bath temperature.

A further possibility of defects caused by changing temperature of the pickling bath may arise from extreme cold. During pickling, iron salts are formed which are soluble in the acid. When the acid has been used for a prolonged period and the amount of iron salt is high, a decrease in temperature may result in the precipitation of these salts. It is well known that the presence of those crystals on pickled ware will probably cause copperheads in the ground coat. The amount of iron salts in the pickle acid which is considered as tolerable differs considerably in various works, but it is good practice to keep the concentration of iron salts not higher than 6 per cent., when the incidence of low temperature in the pickling room can be ignored.

* Iron and Coal Trades Review, 1929, p. 382.

TABLE I.—*Influence of Acid Strength on the Penetration of Hydrogen through Sheet (Edwards).*

Solution used.	4·9 grms. H_2SO per litre.	35·5 grms. HCl per litre.
Deg. C.	Time to transmit 4 cub. cm. H. Mins.	Time to transmit 4 cub. cm. H. Mins.
3·5 ..	492	1,500
12 ..	144	585
50 ..	24	320
75 ..	9·5	64
100 ..	6	8

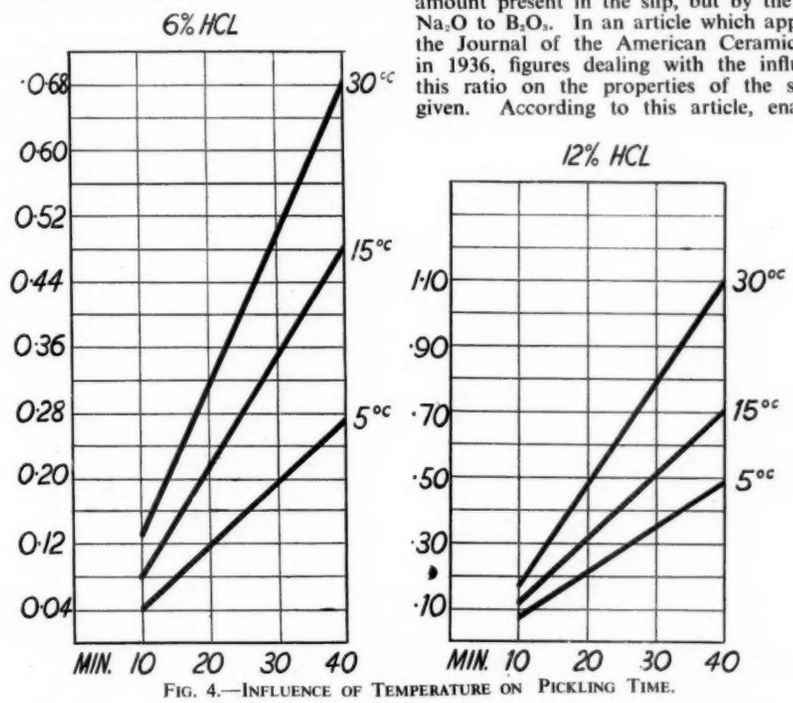


FIG. 4.—INFLUENCE OF TEMPERATURE ON PICKLING TIME.

Summarising the above, it can be stated that a variation in the temperature of the pickle solution profoundly affects the speed of the pickling, and extremely high or low temperatures may create conditions in the pickling shop which result in serious difficulties during the further stages of enamelling.

Influence of Temperature on Milling, Ageing, and the Application of Frits

Many investigations have been carried out in this field, and it has been proved that the influence of temperature on the properties of an enamel slip during the different stages of its production and application is noteworthy.

An enamel slip, it should be understood, is a system containing a suspension of different solid phases in one liquid phase. The particle size of the solid phases varies from colloids to 40-mesh material. The solid phase consists of frit, clay opacifiers and colour oxides. The liquid phase is a water solution containing electrolytes in forms of soluble salts. These salts are present because they have been added as setting-up agents during milling or application, and they are partly the result of the solubility of frit in water.

The properties of an enamel slip, particularly its consistency, depend chiefly upon the following factors:—The amount and kind of colloidal substance in the slip; the degree of peptisation of the colloidal matter; the amount of water in the slip; and the size and specific gravity of the particles. The temperature during milling, ageing and application affects the amount of salts existing in the slip, and thereby the peptisation of the colloidal matter influences the colloidal substance itself and may change the water content of the slip during its application.

The amount and kind of salts which are brought in solution during the milling, ageing and storing of the enamel slip depend upon the kind of frit and the conditions of milling and ageing. The soluble salts consist mainly of sodium oxide, Na_2O, and boric oxide, B_2O_3, and their effect is not only given by the actual amount present in the slip, but by the ratio of Na_2O to B_2O_3. In an article which appeared in the Journal of the American Ceramic Society in 1936, figures dealing with the influence of this ratio on the properties of the slip were given. According to this article, enamels of high Na_2O content (1.5 to 2 grms. per litre), and a low ratio of Na_2O to B_2O_3 (0.8 to 0.9), have an extremely short set. Enamels of low content and a low ratio of Na_2O to B_2O_3 have a good set, and those of high content, 1.25 grms. per litre and a high ratio (1.45 to 2.0), a bad one.

If the milling takes place at a high temperature (65 to 80 deg. C. is considered as normal and most favourable for the milling), the amount of soluble salts will be increased, and the ratio of Na_2O to B_2O_3 will be changed. As a rule, the set will be increased by an increased amount of salts in the mill liquor, and the alteration in the ratio of Na_2O to B_2O_3 will have the following effects. If B_2O_3 prevails, the enamel will keep its set, but may tend to tear and crawl in firing; if the soda content be greatly increased, the enamel loses its set and with an excess of soda and boric oxide there may be a tendency for borax to precipitate during drying, leading to pitting in the fired ware.

Elevated temperature during ageing and storing will show the same results as milling at high temperature, resulting in the amount of salts being increased and the ratio of Na_2O to B_2O_3 being altered. It has been proved, however, that the influence of increased temperature on ageing is less important than on milling, providing the enamel during the ageing is not

agitated. In any case, increased temperature during ageing will result in an increase of soluble salts in the slip; in particular, enamels which have been milled at a high temperature or contain a large quantity of salts according to the properties of the frit or slip, aged at a high temperature for a prolonged period, may contain so large a quantity of salts that a decrease in temperature will cause their precipitation.

Dr. P. G. Bartlett, in an article on "The Tearing of Cover Coat Enamels," published in "The Enamellist," January, 1939, states that storing of cover-coat enamel at an elevated temperature, *i.e.*, over 80 deg. Fah., will increase the tendency to tearing considerably, according to the increased amount of boric oxide in the ratio of Na_2O to B_2O_3.

Another effect of milling at high temperature worthy of mention is described by W. F. Findlay in an article on "Sources of Enamel Shop Waste" (Enamellist, April, 1939); he shows that increasing temperature during milling materially affects the amount of enamel which is retained in the mill after unloading. Increasing temperature increases the set and shortens the draining time, thus affecting the amount of enamel which is held by the lining and the pebbles, and the loss of enamel which takes place when the mill is washed out.

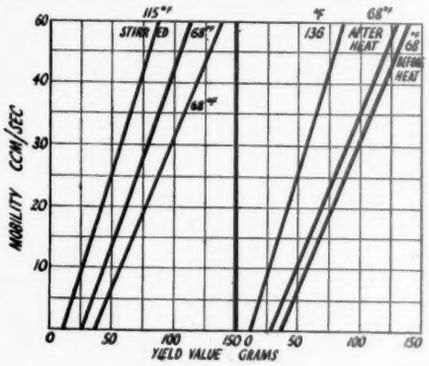


FIG. 5.—INFLUENCE OF TEMPERATURE ON MILLING.

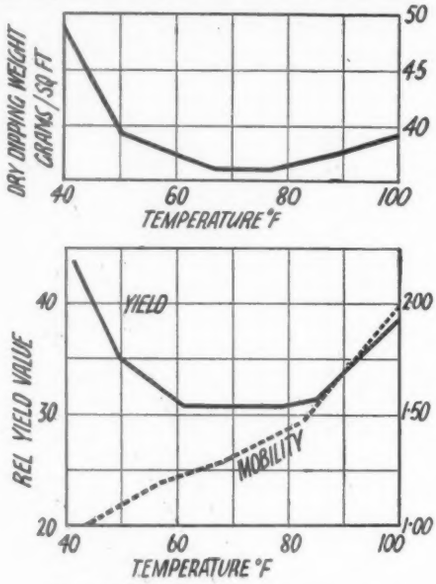


FIG. 6.—INFLUENCE OF TEMPERATURE ON DIPPING WEIGHT.

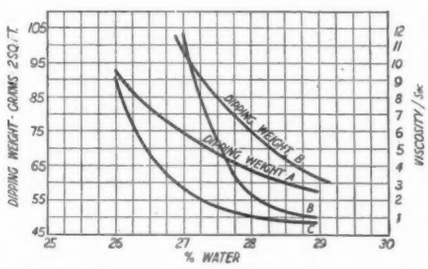


FIG. 7.—INFLUENCE OF WATER CONTENT ON DIPPING WEIGHT.

Figs. 6 and 7 show the results of some experiments carried out by Noble and Lindsay on the influence of temperature on the properties of a ground-coat enamel. In order to show the influence of increasing temperature on the milling, a small amount of enamel was kept at a constant elevated temperature for three hours and the enamel was continuously stirred up during this period. The consistency of the slip expressed by its yield value and mobility was tested before the experiment, after stirring up without cooling, and after cooling, and is shown on Fig. 5. A second curve shows the variation of the consistency when the enamel is kept at an elevated temperature for 24 hours without agitation. The variation in the consistency of the slip which has been heated up to 115 deg. Fah. and has been stirred up is greater than the variation which takes place when the enamel is heated to 136 deg. Fah. but without stirring.

The yield value is the amount of force required to start the flow of the slip, and the mobility gives the rate of flow; in other words, the set of an enamel is controlled in the same manner as the yield value, and the time of set in the same manner as the mobility.

Fig. 6 shows that the dipping weight is increased when the temperature falls below 65 deg. Fah. or raised over 75 deg. Fah., whilst between those two temperatures the dipping weight is nearly constant. The results, taken with a mobilometer under the same conditions, show that the yield value gives the same curve as the dipping weight and that the mobility increases with increasing temperature, thus changing the draining time of the slip. Fig. 7 shows the influence of the water content on the dipping weight and viscosity of a ground-coat slip. Both figures increase with decreasing water content of the slip.

The influence of climatic conditions on the properties of an enamel slip can be summarised by stating that any noteworthy change in temperature during the milling, ageing or application of the slip will affect the properties. Increased temperature during milling and ageing will produce an increased amount of soluble salts and alter the ratio of Na_2O to B_2O_3, thus affecting the set and properties of the slip. Variation of temperature or water content of the slip, caused by warm and dry weather, will affect its draining properties, inducing variation in dipping weight and draining time. A temperature of 65 to 80 deg. Fah. has been found most suitable for the maintenance of proper working conditions during milling, ageing and application. In places where temperatures during the summer season reach 90 deg. Fah. and more, the cooling of mills, dipping tanks and sometimes of the stores will help to maintain uniform properties of the enamel slip. In other places where the temperature variation between summer and winter is considerable, an alteration in the milling formula will help to minimise the possible effects of the variations.

Effects on Drying Processes

The drying process is fundamentally a change of state of water from liquid form to vapour. Water can exist in three phases—solid, liquid and gaseous, according to the temperature and pressure relations, and the change from one phase to another depends on the temperature and pressure. Therefore, any factor which changes the temperature or pressure will also change the state of water and influence the drying.

The molecules of which a substance is composed are in constant motion, the rate varying with the energy of the molecules. If water is heated, some of the hotter molecules rise, and having greater energy move fast enough to break away from the surface. There is a molecular attraction between the free molecules and the molecules on the liquid which tends to draw them back into the liquid. If they possess sufficient energy, they will pass from the zone of molecular attraction. A draft will accelerate this process. Those molecules which are freed at the surface exert a pressure called the vapour pressure of the water; this pressure is proportional to the concentration of the vapour. The air contains a small amount of water in vapour form called humidity. This water vapour also exerts a vapour pressure, tending to oppose the vapour pressure developed from the water. Thus, temperature, humidity and air currents affect the drying. The coat of enamel which is to be dried is composed of frit of different size and clay, the voids being filled with water.

The evaporation of water takes place at the surface, and as the drying continues more water is brought up to the surface by capillary attraction. The clay shrinks with the loss of water and tends to reduce the pore system through which the water vapour must pass. As the water evaporates it leaves behind, at or near the surface, those salts which were carried in solution. This concentration of salts near the surface causes a surface film which is different in composition from the body of the coat. When the heat is applied too rapidly to the surface of the enamel, the evaporation rate at the surface is more rapid than the rate of flow of water to the surface. The zone of evaporation moves into the enamel and causes shrinking of the clay and sets up strains in the enamel coat which induce minute cracks, liable to cause tearing in the fired enamel.

When the air is extremely dry, the top of the enamel tends to dry out before the water in the lower level has come to the surface. A hard crust or skin forms over the enamel, chiefly due to the salts left at the surface, and prevents any further capillary action by trapping the water in the interior. This water may cause cracks in the dried enamel when the drying continues, and the water vapour forces its way through the dry surface, or, if the evaporation of this residual moisture is delayed, it may cause blisters or popping-off of the enamel during the firing process. Enamels which contain a high amount of salts through long ageing, or ageing at high temperature, tend to favour the formation of such a skin on the surface. If this film be less porous or more brittle or has a greater shrinkage, further drying will cause cracking and tearing during the fusing.

The order of influence of climatic conditions on the drying process depends largely on the type of drying equipment in use. When the dryer is of a type in which temperature and humidity of the air and the amount of air circulation are all controlled and automatically altered according to the changing temperature and humidity of the atmosphere, no influence can be expected. The type of dryer generally used in the enamelling industry, however, has only the temperature controlled, and the amount of air in circulation constant but the influence of humidity is neglected. If the temperature is controlled automatically and kept at a certain level independent of the changing air temperature outside of the dryer, an effect of variation in the humidity of the air will only be noticeable when the humidity is extremely low or when other circumstances enhance the effect of low humidity. This may happen when

the dryer is only partly filled, and thus the amount of circulating air becomes proportionally too high.

If a type of dryer is in use where the temperature can only be controlled by regulating the fuel supply by hand, the influence of changing temperature and humidity will naturally be of greater importance. The extent of difficulties which may be caused by drying conditions as influenced by weather depends not only on these conditions, but is deeply affected by various other conditions, such as fine-milled enamels; slips containing a high amount of soluble salts; low content of clay; thickness of the enamel layer and the shape of articles. Very often only the accumulative influence of these factors will cause such drying effects as tearing or curling, shorelining, popping of the dry coat before fusing and unfavourable conditions for brushing or stencilling.

When the enamel ware is dried in the open air of the shop, the drying conditions are more or less uniform, but the rate of drying is greatly influenced by atmospheric conditions. When the weather is cold and the humidity high, the drying rate is very slow and rust spots or copperheads in the ground coat may be caused.

Influence on Firing Process

Ebright and McIntyre in 1933 outlined the results of investigations on the effects of water vapour on porcelain enamel during firing ("Enamellist," April, 1933). The reason for these investigations was apparently difficulties experienced during the firing in continuous furnaces during a period of high humidity in the atmosphere. The firing of cast-iron ware under those conditions caused blistering and the appearance of a dull surface—a sort of greasy lustre appeared—while copperheading, blistering and boiling of the ground coat or black specks in the cover coat were the main troubles during the firing of sheet-iron parts. The control of the furnace atmosphere showed that in a period of high humidity the figures for the water-vapour content of the furnace atmosphere were 6 per cent. or more, while only 1 to 3 per cent. of water vapour was present in periods of low humidity.

Further investigations of these conditions have been carried out since, with the following results:—The normal atmosphere of an enamel shop averages 2 to 3 water vapour; 78 to 79 nitrogen; 19 to 20 per cent. oxygen; and traces of carbon dioxide (by volume).

Changing weather conditions alter the amount of water vapour in the air, while the nitrogen oxygen ratio of 5:1 is fairly constant. As long as the furnace atmosphere approximates that of the normal shop, no trouble should be caused by the water vapour. Increasing humidity in the furnace atmosphere results in pronounced difficulties during the firing process. A moisture content of 10 per cent. by volume in the firing zone will usually cause trouble from blistering, copperheading, and generally poor surface texture in wet-process enamels. Wet-process cast-iron enamels are more susceptible to excess moisture than sheet-steel enamel, and a concentration of 3½ per cent. by volume of water vapour will cause serious blistering and scumming.

The presence of water vapour in the furnace can be influenced from several sources, namely, from a high humidity condition of the atmosphere, from the enamel itself, and from leaky muffles. From every 100 lbs. of enamel fired, approximately 1 lb. of water is vapourised from the clay, as an average of 7 lbs. of clay per 100 lbs. of frit is used, and every pound of clay contains 10 to 15 per cent. of water by chemical combination. This amount will be increased when the goods are not completely dry when entering the firing zone. A high amount of water vapour may be added to the furnace atmosphere when the muffle leaks, allowing varying quantities of flue gas (which usually contains large quantities of water vapour) to leak into the furnace atmosphere.

Difficulties caused by high humidity in the furnace are more frequently observed with continuous furnaces than with box-type furnaces, yet difficulties personally experienced through high humidity in an oil-fired box-type furnace are worth recounting.

A Practical Example

The hollowware production of an Austrian firm, over a period of about 18 months, consisted partly of very cheap kitchen ware, such as pots and pans enamelled in a one-coat finish. It was a blue ground-coat enamel, and the articles were produced at an average rate of about 2,000 to 3,000 lbs. of finished goods a day. They were sold at a very cheap price in order to end a price war and establish production control in the enamelling industry with a result favourable for the firm. Naturally the profit margin of such articles was very small, and the management insisted upon daily reports as to output, rejects and reprocessing. A few weeks after the production of this article had started, severe copperheading suddenly occurred. For a period of about 48 hrs. nearly the whole production of this article was spoiled through raised and depressed copperheads. As suddenly as the trouble started, it disappeared.

During the next few months the sudden appearance of severe copperheading happened again—sometimes at intervals of a few weeks, sometimes of a few days only, and at other times only for a short period during the day, particularly in the early morning when the ware which has been dipped at night was fired. This obviously caused much trouble, and therefore the whole process of production had to be examined, in order to find a reason for those troubles. Beginning from the sheets and raw materials for the frit, all the different stages of enamelling were controlled. All conditions during pickling in the composition and production of the frit, during the milling, ageing and application of the enamel, which seemed to be most favourable for successful work, were kept unchanged and under strict control, but only with the result that after a while the appearance of copperheads restarted.

TABLE II.—*Influence of Temperature on Ground-Coat Enamel (Noble and Lindsay).*

Water temperature. Deg. C.	Solubility. Grms. per litre. $Na_2B_7D_7$.	Solubility. Grms. per litre. Borax crystal.	Solubility. Grms. in 100 kg. enamel slip (= 33 litres H_2O).
5	13	25	812
6	14	27	878
7	14	27	878
8	15	28	937
9	15	28	937
10	16	30	1,003
15	20	38	1,251
20	25	47	1,561
25	32	61	2,003
30	39	74	2,249
	H_3BO_3 boric acid.	—	
0	26		858
12	37		1,294
31	49		1,617
	Soda (calcined).	—	
0	70		2,310
5	95		3,135
10	120		3,960
15	160		5,346
20	215		7,095
25	285		9,405

TABLE III.—*Influence of Slip Temperature on Draining Qualities during Unloading.*

Temperature. Deg. F.	Drain time. Seconds.	Deposit Grams.
63 ..	10	13·5
72 ..	8·5	14·25
80 ..	7·5	16
88 ..	7·1	18
96 ..	6·0	15
102 ..	5·1	17·5

One day, someone humorously suggested blaming the weather. The remark was taken seriously and the influence of the weather was checked. Weather reports and production reports were compared, and it could be proved that there was a coincidence between the appearance of copperheads and periods of high humidity in the atmosphere, usually accompanied by low temperature. The control of the furnace atmosphere showed that during periods of high humidity the amount of water vapour in the furnace was increased up to 8 per cent. per volume. The examination of the drying and firing process showed that during cold and wet weather the ware which had been dried in the open air on top of the flue pipes was not completely dry when fired. During conditions of high humidity, heavy firing loads of this ware, whilst still moist, added so much water vapour to the already drastically increased humidity of the furnace atmosphere that, after a few loads, a concentration of water vapour was reached which caused copperheads. Later on, in order to remove the influence of weather conditions, the ware was dried in a covered dryer and the muffle fed with dry air. After a slight alteration in the frit composition, which gave better firing conditions, copperheading on these articles ceased.

The amount of trouble which may be caused by climatic conditions will largely depend upon the coincidence with other factors which may increase or reduce the tendency to difficulties. Suitable measures against the influence of extreme weather conditions and a strict control of the whole enamelling process will reduce those difficulties and secure uniform working conditions.

The author expresses his thanks to Mr. B. B. Kent for the help given in the preparation of the Paper.

Iron and Steel Institute

MR. JOHN CRAIG, C.B.E., D.L., Vice-President, has been nominated to succeed Lord Dudley as President of the Iron and Steel Institute for two years, and to take office at the Annual Meeting, 1940. The presidential address will be read at the Annual Meeting, which, subject to unforeseen circumstances, will be held in London on Thursday and Friday, May 2 and 3, 1940. The programme and list of Papers presented for discussion will be announced later.

The date and place of the Autumn Meeting have not yet been fixed, but the Council propose to arrange a meeting in September, at which Papers will be presented and discussed.

The Institute will continue to print technical and scientific Papers of interest to its members (except that Papers containing matter likely to be useful to the enemy will be censored or held over until after the war). Authors are invited to submit Papers. Suitable Papers will be selected for discussion at general or special meetings, or at joint meetings with other societies; discussion by correspondence is invited.

Advance copies of Papers, presented for discussion at the Annual and Autumn Meetings, will be available to members before the meetings as usual. In addition, the Council have authorised the distribution of at least one Paper each month to members in advance-copy form.

The Week's News in Brief

Trade Talk

THE SPRING MEETING of the American Society for Testing Metals is to be held in Detroit from March 4 to 8.

A CHRISTMAS DINNER for 1,500 night workmen of the Metropolitan-Vickers Electrical Company, Limited, at Trafford Park was provided at 1.30 a.m. on Thursday, December 21, in the works' canteen.

SOCIETE OUGREE MARIHAYE, in the year to June 30 last, made a profit of 113,700,000 fcs., as against 115,700,000 fcs. in the previous year. Depreciation account again received 45 million fcs., leaving 70,471,000 fcs. for distribution, as against 71,252,000 fcs.

THE HAMMOND LANE FOUNDRY, Dublin, has agreed to give all workers over 18 3s. per week increase and those under 18 1s. 6d. per week increase as a war bonus, retrospective to September 1. About 200 men and women come under the arrangement.

NET PROFIT of the Société Métallurgique d'Esperance-Longdoz for 1938/9 was 47,048,022 fr., against 40,029,836 fr. in the previous year, after writing off for amortisation 14,321,036 fr. against 20,599,784 fr. A dividend of 270 fr. per share, against 200 fr., has been paid on the 75,000 shares.

THE SUM of £513 1s. 4d. was disbursed to employees of the Brockhouse Castings, Limited, Wednesfield, Wolverhampton, on Friday last under the profit-sharing scheme. Mr. J. T. Brockhouse, chairman, who was accompanied by Group Captain F. A. Baldwin, director, distributed the amounts.

THE NEXT MEETING of the Wales and Monmouthshire Branch of the Institute of British Foundrymen will be held at the University College, Newport Road, Cardiff, on January 13 at 3 p.m., when a discussion on "Wasters" will be introduced by Mr. S. Southcott, a Past-President of the Branch.

THE MINISTRY OF LABOUR AND NATIONAL SERVICE announces that the address of the Central Register as from January 1, 1940, is as follows: The Secretary, The Central Register, Ministry of Labour and National Service, Queen Anne's Chambers, 41, Tothill Street, London, S.W.1. Telephone: Whitehall 7010.

THE ANNUAL DINNER of the South Wales Institute of Engineers, usually held on the election of a new president, has been abandoned, but it has been decided, instead, to hold a special Institute luncheon at the Park Hotel, Cardiff, on Thursday, January 18, at 1.30 p.m., to commemorate the opening of the new session by Mr. George Roblings, who has been re-elected President.

ABOUT TWO YEARS ago we printed details of the World's largest magnetic drum made by the Rapid Magnetting Machine Company, Limited, of Magnet Works, Lombard Street, Birmingham, 10. It was installed in a sugar plantation in Africa and in its first year extracted from the cane about a quarter of a ton of tramp iron. This effected a saving of some £500.

NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Glasgow, has received an order from the Ministry of Supply for 100 locomotives of the 2-8-0 Class with tenders, for use in France. The contract ensures, along with work on hand, a busy time during next year. The total number of locomotives ordered by the Ministry is 240, and orders are also expected by R. Y. Pickering & Company, Limited, Wishaw, and Hurst, Nelson & Company, Limited, Motherwell, for wagons.

AN authoritative statement regarding the International Nickel Company's property in North Finland points out that the mines are in process of development. They are considered to have valuable deposits of nickel, copper and ore of a kind that exists in Canada, but which is unequal in quantity to the Canadian mines. In order to produce ore and matte a great deal of preparatory work has still to be done, such as the installation of hydro-electric power. This was in course of construction just before the war broke out between Russia and Finland. At the outbreak of hostilities all construction work was stopped, and a considerable amount of development has to be undertaken before the production stage is reached.

FOUNDRIES IN FALKIRK and district closed down on Thursday and Friday last for the New Year holidays. On this occasion the holiday period is to extend over a period of ten days, while at others a resumption will be made on January 8. For many of the foundry workers, unfortunately, an even longer spell of idleness is in prospect as a result of the light castings industry having been severely hit by conditions arising out of the war. Consequent upon the Government's order suspending practically all house-building schemes, there has been a serious slump in the demand for housing materials of a nature which form the principal products of the industry. As a result many foundry workers have had to be suspended for an indefinite period, while others are getting short-time employment only. The industry's unemployment figures remain at practically the level at which they were at the end of last year, but that gives little indication of the real state of trade, as large numbers of men who were engaged in the light castings industry have left to serve with the Forces.

IN a New Year message, Mr. Guy Locock, Director of the Federation of British Industries, says that British industry can face 1940 in good heart. Its response to the call of war has amply demonstrated its adaptability and resource. Immediately before the war, trade reached a high level of activity, and, despite the inevitable difficulties following on the transition from peace to wartime organisation, the export situation is improving. The great task before us is twofold, says Mr. Locock. First, the supplying of the needs of civil defence and the fighting forces, and, second, the maintenance, as far as possible, of our home and overseas trade. The vigorous functioning of the export trade is vital. Service orders must, of course, take priority, but nobody doubts the significance of the economic weapon by which Germany's previous markets can be won and our own existing markets held. To fulfil this task, manufacturers must be able to rely on a continuous flow of the necessary raw materials, and on the provision of plant and man-power and reasonably stable prices. Exports have been described as Britain's fourth arm, and industry is fully alert to their significance.

Obituary

MR. WILLIAM MERRILEES BAIRD, managing director of William Baird & Son, Limited, structural engineers, Temple Ironworks, Glasgow, has died at the age of 60. He was a son of the founder of the business.

MR. JOHN DANIA TOMLINSON, chairman of Tomlinsons (Rochdale), Limited, Soho Ironworks, Rochdale, founded by his father, the late Mr. James Tomlinson, nearly 90 years ago, died recently. He was 78 years of age.

WE MUCH REGRET to announce the death of Mr. John Chadwick which took place on December 27 at Colwyn Bay. Mr. Chadwick was formerly the proprietor of a foundry business at Gray Street, Bolton, which now bears the name of his son, Mr. J. N. Chadwick. Mr. Chadwick was a life member of the Institute of British Foundrymen and for many years took a live interest in the activities of the Lancashire Branch. To Mr. J. N. Chadwick, also a life member of the Institute, we offer our sincere sympathy.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

George H. Elt, Limited, Eltex Works, Bromyard Road, Worcester. Capital, £10,000. Sheet metal workers. Directors: G. H. and M. E. Elt.

Grice & Young, Limited, 19A, Albion Street, Dunstable—Capital, £6,000. Engineers. Directors: J. B. G. Grice, W. E. Seamons, and D. M. Grice.

Hoffmann Gloucester, Limited, Stonehouse, Gloucestershire—Capital, £250,000. Iron and steel converters, etc. Directors: T. W. Cooper, F. C. Pryke, F. Armitage, P. Butchard, and C. H. Smith.

Non-Ferrous Founders, Limited, 114, Bradstock Road, Ewell, Surrey—Capital, £2,000. Director: W. Dainton.

Company Limited by Guarantee

St. Pancras Metal Industries, Limited—To combine and pool resources of firms in metal industries, etc. Management is vested in a Council. Subscriber: J. A. Benson, 69, Moorgate, London.

Personal

MR. ROBERT YEOMAN has changed his address from 110, Derby Road, Loughborough, to 23, Oaklands Road, Swinton, Manchester.

MR. R. TAYLOR, managing director of Muirhall Foundry, Larbut, and Mrs. Taylor were last week presented with a silver salver by the staff to mark the occasion of their silver wedding.

MR. M. HARLEY, who is retiring from the position of works timekeeper at Callendar Abbots Foundry Companies, Limited, Falkirk, has been presented with a canteen of cutlery by his colleagues.

ENGINEER-CAPTAIN G. Villar, R.N. (retired), has been appointed engineering works manager at the Woolston works of John I. Thornycroft & Company, Limited, in succession to the late Mr. Robert Mackie.

MR. ROBERT TODD, who is now 82 years old, has had 63 years continuous service with Kelvin, Bottomley & Baird, of Glasgow, and was last week presented with a wallet of treasury notes. The presentation was made by Mr. Fred C. Stewart, the chairman of the company. Mr. Todd is not retiring.

SIR HARRY BROWN has accepted a position as chairman and managing director of the British General Electric Company Proprietary, Limited, the Australian subsidiary of the General Electric Company, Limited, and will take up his duties on January 1. Mr. Edward Hirst will be associated with him as joint managing director and vice-chairman.

Reports and Dividends

Greenwood & Batley, Limited—Interim dividend of 3 per cent.

Climax Rock Drill & Engineering Works, Limited—Interim dividend of 2½ per cent.

Union Steel Corporation (of South Africa), Limited—Final dividend of 3 per cent. on the ordinary shares, making 6 per cent. for 1939.

International Combustion, Limited—Dividend of 12½ per cent., making 20 per cent., and a bonus of 12½ per cent.

J. Brockhouse & Company (Ireland), Limited—Profit to October 31 last, £7,251; debit balance brought in, £11,768; debit forward, £4,517.

Nasmyth Wilson & Company, Limited—Profit for 1938, £2,018; transferred from reserve, £5,500; debit balance brought in, £7,149; credit forward, £368.

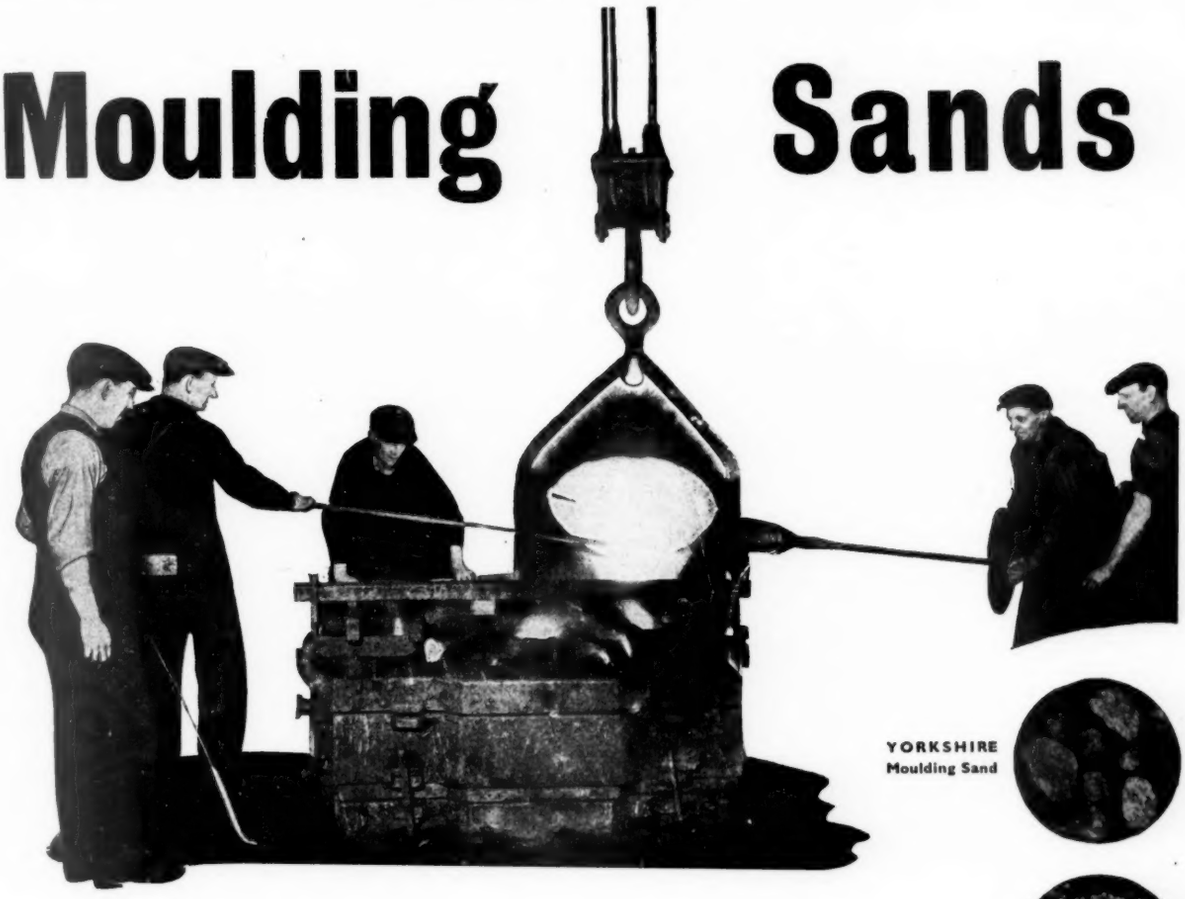
Ley's Foundries & Engineering, Limited—Consolidated trading profits, etc., of company and its subsidiaries for the year to September 30, £193,905; net profit, after taxes, £93,758; net earnings of the parent undertaking alone, £65,668; brought in, £15,918; ordinary dividend of 11 per cent.; carried forward, £23,473.

R. A. Lister & Company, Limited—Profit for the year ended September 30, after depreciation, £219,417; brought in, £70,296; provision for contingencies not now required, £30,011; income tax, £94,138; N.D.C., £11,348; preference dividend, £13,050; interim ordinary dividend of 5 per cent., £23,172; final dividend of 5 per cent. and bonus of 6 per cent., £45,704; directors' commissions and staff bonus, £31,351; to general reserve, £25,000; carried forward, £75,961.

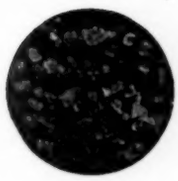
A.R.P. Shelter Lighting

The British Standards Institution have issued a publication dealing with the lighting of air-raid shelters (BS/ARP 6) which points out that the most important feature of this revised edition is the inclusion of a section detailing the equipment to be provided in cases where direct-current mains are available. The original issue of the Specification appeared to have been drawn up with alternating-current mains only in view, with the result that numerous queries arose as to what should be done in areas where the mains supply was direct current. This anomaly has now been removed. The Specification for the lighting of large shelters is based on the principle that whereas in small shelters a battery installation is satisfactory as a stand-by, in large shelters a self-contained generator unit is advisable. The Specification gives full details of the generator and battery-charging equipment, together with particulars of the number of lamps and their wattage. Copies of the Specification may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1. (Price 6d., post free 8d.)

Moulding Sands



YORKSHIRE
Moulding Sand



THANET
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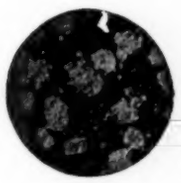
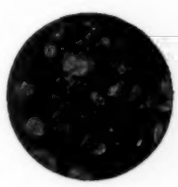


YORK YELLOW
Moulding Sand



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Raw Material Markets

Iron and steel makers have entered the New Year with order-books very full, especially in the case of steel. Foundries, on the whole, are busy and prospects are that there will continue to be plenty of work available for them throughout the year. Heavy foundries are engaged on Government contracts, and, while light foundries are not yet well supplied with this type of work, they are hopeful of securing employment of a national character in the near future. Fresh deliveries of iron and steel are carefully regulated by the Control, and there are few complaints of the system from consumers. Works have mostly restarted operations following the Christmas and New Year holidays, and the annual inventories this year have been carried out more quickly than usual.

Direction (No. 2), dated December 22, under the Control of Iron and Steel (No. 4) Order, 1939, to come into operation as from January 1, has been issued by the Ministry of Supply. The new Direction supersedes the Direction (No. 1) issued at the same time as the No. 4 Order. The main features of the new Direction are that the exemption of pre-war contracts from the requirement of a licence disappears, and in future deliveries under such contracts will be subject to the licensing provisions of the Order, and, except in the case of departments of the United Kingdom Government, the existing exemptions from licence have been restricted to purchasers of materials for use in the United Kingdom. In addition, purchases of home iron ore, pyrites ash, burnt pyrites residues, and boot and shoe grindery for use in the United Kingdom have been exempted from licence. Amendments have also been made in the provision for sale and purchase of small quantities of material without a licence. Eight additional related price schedules have been deposited.

Pig-Iron

MIDDLESBROUGH—The turn of the year marked the conclusion of four months of war, and general satisfaction is felt at the progress made in the efforts to put industry on an emergency footing. Production is at record levels, and consumers are being well supplied with material, although no provision is made for stocking, and, in fact, extensive reserves are not sanctioned by the Control, as it is desired that all users shall be able to obtain deliveries necessary to them to maintain their immediate outputs. There is a strong potential demand for Cleveland foundry iron, but this type of iron is still not being made and producers' stocks are nearly exhausted. Suitable alternatives, however, are available from other areas.

Supplies of hematite are being made available for consumers in the Midlands on quite a good scale, despite the heavy requirements of the local steelworks. Shipments to South Wales, too, are being made quite freely. Stocks are not now very large at makers' works, but the current production is very gratifying, and there are prospects of an increase in the near future.

LANCASHIRE—Most foundries in this area have begun the New Year in a favourable position. Light-castings makers still are in need of additional employment before they will be able to operate on a full-time basis, but the outlook in this connection is improving, as it is likely that 1940 will witness an increase of Government contracts for these concerns, which have so far been rather neglected in this respect. Derbyshire and other Midland descriptions of pig-iron are in request in large tonnages, while hematite, also, is being consumed satisfactorily.

MIDLANDS—Heavy foundries in this area continue to be well employed, but there is still a scarcity of work among the light foundries. Additional Government contracts are required to place this section on a more satisfactory footing, but this appears to be forthcoming only slowly, and the trade is able to operate only short time. This has been the case for many months past, and the quietness of housebuilding continues to be difficult to overcome. Heavy engineering foundries and machine-tool makers are starting the New Year with full order-books, and there is little likelihood of any falling away in these branches for a long time to come. Consequently, large tonnages of hematite and low-phosphorus iron are being called for regularly, while smaller supplies of high-phosphorus iron are also used. Production of low-phosphorus material is now improved and users are getting a more equitable distribution.

SCOTLAND—The New Year holidays are being taken at works in this country, but less time generally is being given to employees on account of the active conditions at present prevailing. Repairs are being carried out this week, while stocktaking activities are also due, but a resumption of production is being made as speedily as possible. Local steelworks are especially busy and are taking heavy tonnages of basic iron, while the turnover in hematite is also quite good. The last month or two of 1939 witnessed a steady improvement among light-castings foundries, but many of them remain badly situated for new orders. Iron for these concerns largely comes from the English Midlands.

Coke

As reported in our last issue, the price of foundry coke has been raised by 2s. 6d. per ton, making the current quotation for delivery in the Midlands 53s., minimum. Most coke ovens had already made extensive contracts before the higher price was introduced, but a rise-and-fall clause was stipulated in new transactions, thus safeguarding producers against the policy of the Control. Deliveries are being made satisfactorily.

Steel

Never before has the British steel industry entered a year with such a pressing demand for its products as is the case in 1940. However, the industry has never before been so favourably placed to meet these requirements, and, with outputs at record levels, the outlook cannot be said to be unsatisfactory, as wartime needs should be met in an adequate manner. Consumers of steel are receiving steady deliveries, and, although it is not now possible to accumulate reserves, it is felt that the industry will be able to maintain a satisfactory service during the year. Export inquiries are being met in some small part, and it is anticipated that increased attention will be paid to the overseas markets later.

Scrap

Some indication of the early results of the campaign for the collection of scrap by the British Iron and Steel Federation was given here last week, and it is felt that the campaign promises to be even more gratifying than was at first expected. Holidays have resulted in a slightly quieter tone in the market recently, but there is no indication of any lessening of requirements, the steelworks, especially, continuing to take up all they can acquire.

Metals

The turn of the year has had little significance for non-ferrous metal markets generally, as, with the exception of tin, the markets are pegged down by the Control, which has fixed maximum prices.

Copper—Consumers of copper continue to be very actively employed, and consumption is running at a high rate. There is every prospect of this continuing to be the case, as the use of the red metal in wartime production is very extensive. While the German U-boat campaign has undoubtedly involved a certain loss of supplies destined for the United Kingdom, the convoy system is ensuring a steady flow of arrivals, although the convoys are at times rather tardy, and, moreover, a big tonnage of metal originally intended for Germany has been intercepted. Japan has recently bought 1,500 short tons of copper in the United States, but Russian inquiries for 5,000 tons there have not resulted in any business being done, despite the fact that the U.S.S.R. was prepared to pay 12.75 cents, f.a.s., as compared with the general American export price of around 12.50 cents per lb., f.a.s. A new output record for Canadian copper is reported to have been set up by the Dominion last year. The quantity was 606,705,000 lbs., against 571,250,000 lbs. in 1938.

Tin—This market has opened the New Year on a rather happier note than was earlier thought might be the case. The freeing of the market has to a large extent solved supply difficulties, and business is now settling down quite satisfactorily, with producers obtaining a more economic return for their sales. Export licences for tin are still unobtainable except for France. A price of 50 cents per lb. is reported to have been offered by Russia for spot tin in the United States, but inquiries are believed to be meeting with scant success.

Mr. W. H. Gartsen (Henry Rogers, Sons & Company) reports that the total visible supply of tin on December 31 was 25,020 tons, compared with 28,319 tons at the end of the previous month. The carry-over in the Straits Settlements was 6,394 (4,375) tons, while the carry-over at principal European smelters (other than British Tin Smelting Company) was 6,291 (4,676) tons.

Spelter—Urgent demands for this metal appear to be satisfied without undue delays. Consumption is undoubtedly very heavy, but in the absence of any comprehensive data, it is impossible to compile an accurate statement in this connection. The chief working-up industries are all operating at a high rate.

Lead—While cable and battery makers and other consuming trades continue to be very busy, there is little indication of an improvement in housebuilding, which has been slack for a considerable time past. Concerns working on Government contracts are well provided with work and consumption of lead is heavy.

Hand Hammers

The British Standards Institution have just issued, in close co-operation with the Edge Tools Manufacturers' Association, a specification for hand hammers (B.S. No. 876), which deals with joiners', engineers', smiths', stonebreakers' and boiler scaling hammers. The Specification was prepared at the request of the Institution of Mechanical Engineers and is intended to cover all the hand hammers in general use. Both form, dimensions and weight are dealt with and requirements are included governing the quality of the material used, together with practical tests on the hammer, etc. Nine sizes of joiners' hammers are specified between 4 and 20 ozs. in weight. Eleven sizes of engineers' ball, cross and straight pein hammers are dealt with between ¼ and 3 lbs. in weight. Twelve sizes of sledge hammers—double face and cross pein—are included between 1 and 16 lbs. in weight. Six smiths' and club hammers are included between 1½ and 4 lbs. in weight. Five sizes of stonebreakers' hammers are included between 1 and 2 lbs. in weight. Three sizes of boiler scaling hammers of 1, 1½ and 1½ lbs. in weight. Two pin hammers of 3½ and 4 ozs. in weight.

Copies of the new Specification (No. 876-1939) can be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 2s. 2d. post free.

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